GALLOWAYS

LIMITED

BOILERS

BOILERS

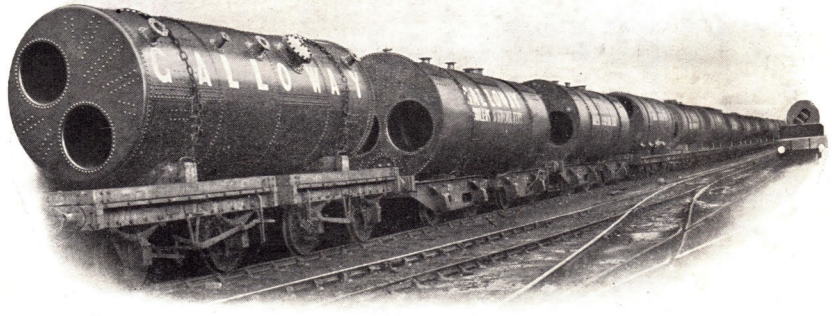
GALLOWAY BOILERS DRY BACK BOILERS

LANCASHIRE BOILERS WASTE-HEAT BOILERS

CORNISH BOILERS SUPERHEATERS

SEE SEPARATE CATALOGUE FOR BOILER FITTINGS

Oil storage Tanks, Kilns, Kiers, Stills and Plate work of all descriptions (see separate circular)



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Boilers for Collieries, Steel Works, Factories and Electricity Works

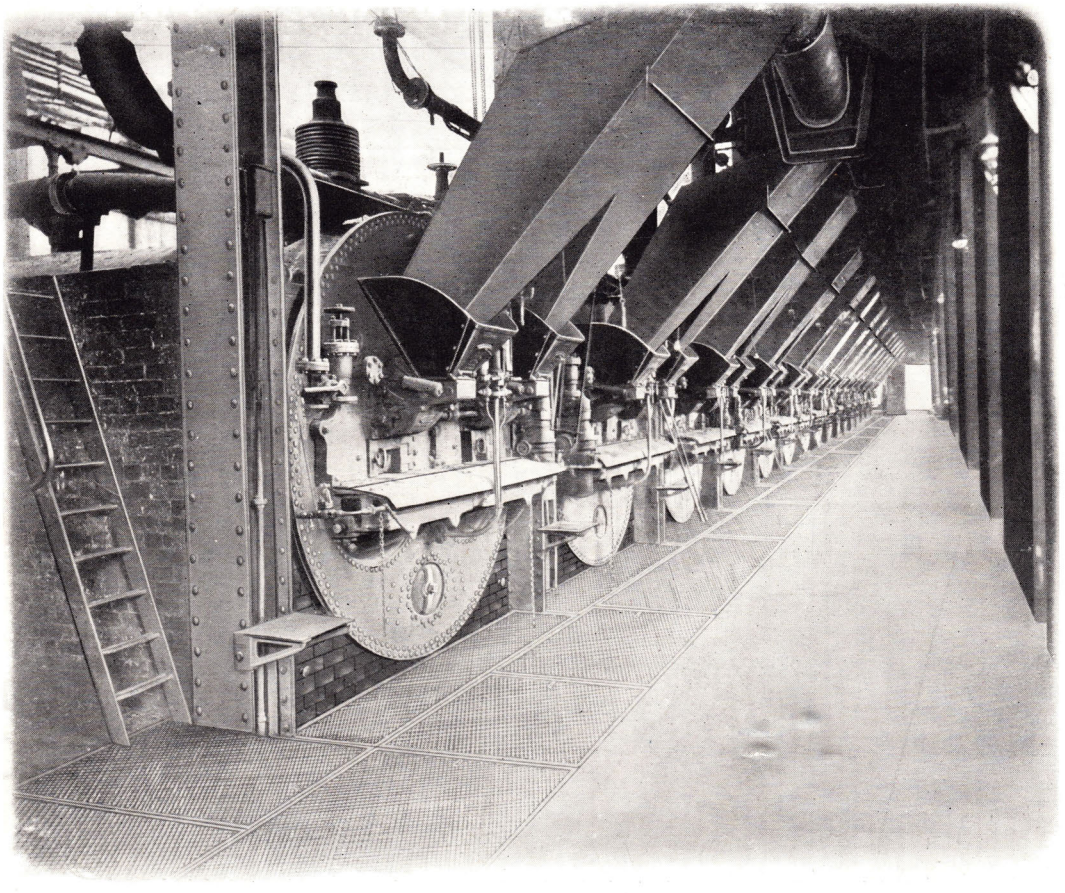


Fig. 1. Battery of sixteen Lancashire Boilers, 30 ft. long, 9 ft. diameter, 160 lbs. working pressure.

Oil storage Tanks, Kilns, Kiers and Plate work of all descriptions

BOILERS

THE firm of Galloways, Ltd., was founded about a century ago and during that long period has steadily maintained, in the ever changing phases of engineering, a commanding position in the manufacture of engines and boilers. Originally both branches of the business were carried out at the Knott Mill Works, Manchester, but about 1872 the extension of boiler manufacture made a new works necessary and this was built on a new site at Ardwick, Manchester. Several extensions were made in due course but in recent years additional shops have been erected and equipped with a large number of modern machine tools for bending, flanging, welding, drilling, rivetting, etc., to ensure increased output and to maintain the accuracy of finish so necessary in high-class boiler work.

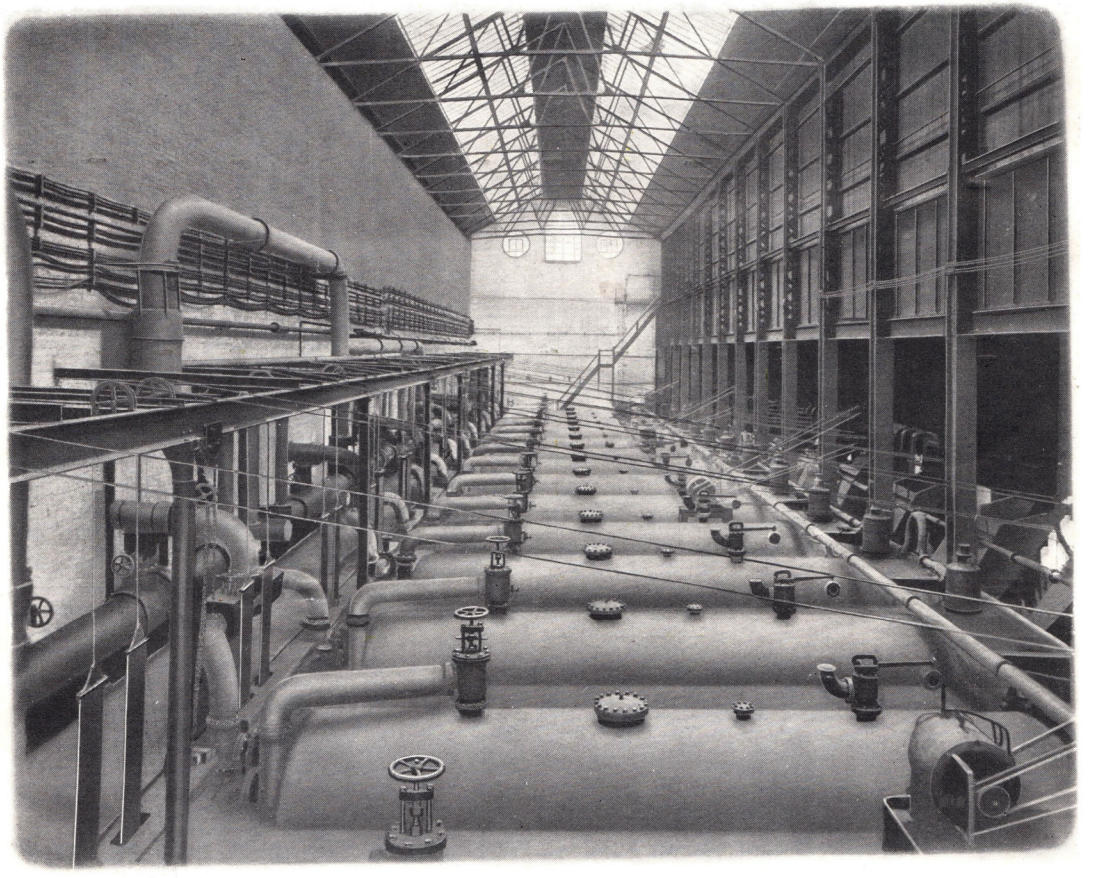


Fig. 2. Battery of sixteen Lancashire Boilers, 30 ft. long, 9ft. diameter, 160 lbs. working pressure. View of top of Boilers.

A recent addition to the pressing and flanging plant at the Ardwick Boiler Works is a new 1,500-ton Flanging Press. This press has been specially designed and constructed by Galloways, Ltd., for performing all descriptions of heavy flanging work, such as dished end plates of Lancashire Boilers which are flanged with one single heat only.

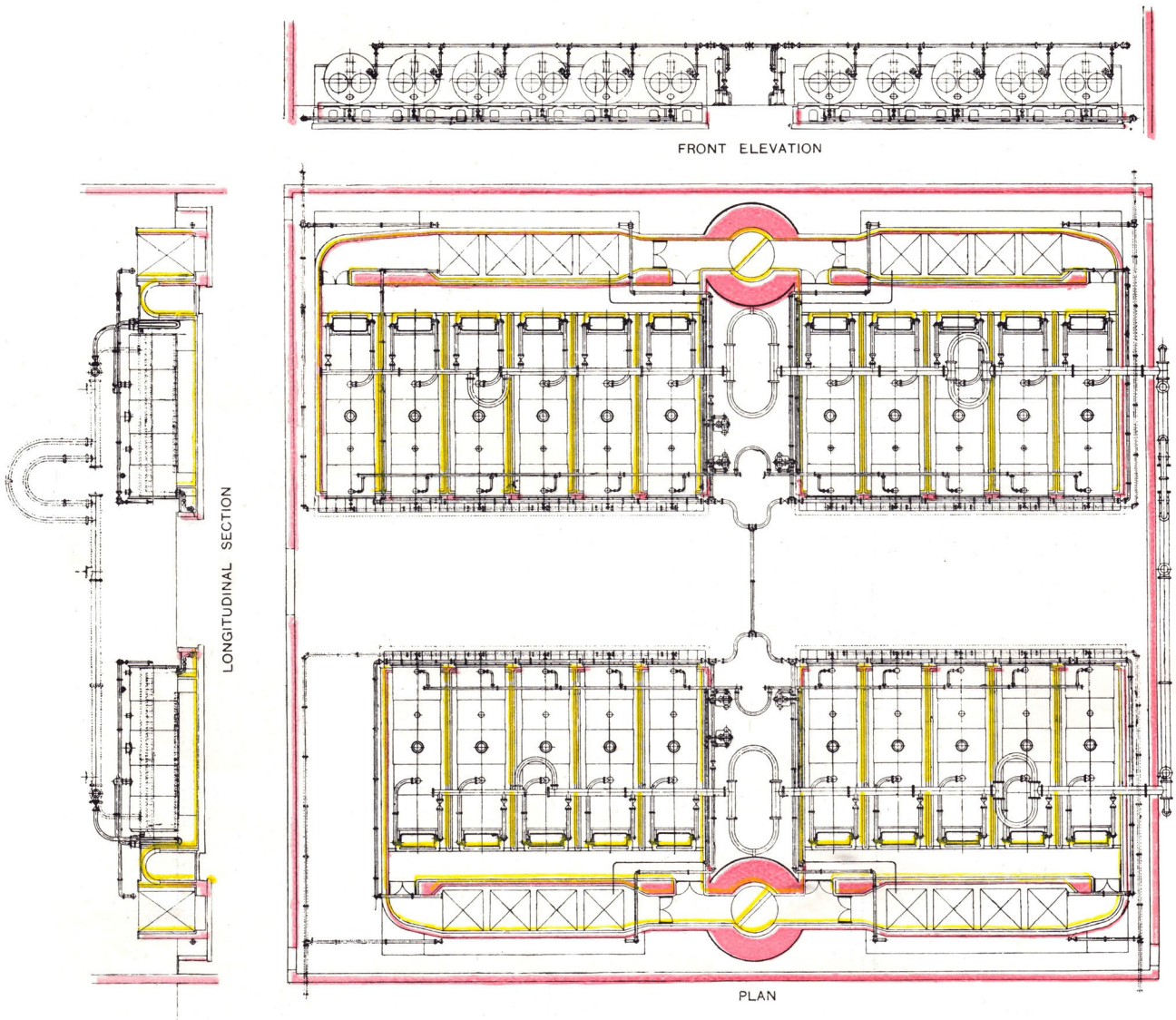


Fig. 3. The line drawing shown above illustrates a battery of twenty-one Lancashire Boilers, 30 ft. long by 8 ft. 6 in. diameter, with a working pressure of 160 lbs. per square inch.

This installation will generate approximately 168,000 lbs. of steam per hour under satisfactory conditions.

About 16,000 Lancashire, Galloway and Cornish Boilers have been supplied to all parts of the world in sizes ranging up to 32 ft. long by 9 ft. 6 ins. diameter and for working pressures up to 225 lbs. per square inch. The design has been continuously improved and the boilers, as now made, are singularly free from grooving and other upkeep troubles. All boilers are constructed with a factor of safety of five and to pass any English Insurance Company, the Board of Trade Rules and the various Indian Government requirements.

Special and careful attention has been paid to the design and arrangement of the gusset stays in the modern boilers constructed by Galloways, Ltd., in order to secure the desired flexibility of the stayed flat end plates, and thus reduce to a minimum the difficulties due to the constant expansion and contraction which necessarily exist in a varying degree in all parts of a boiler.

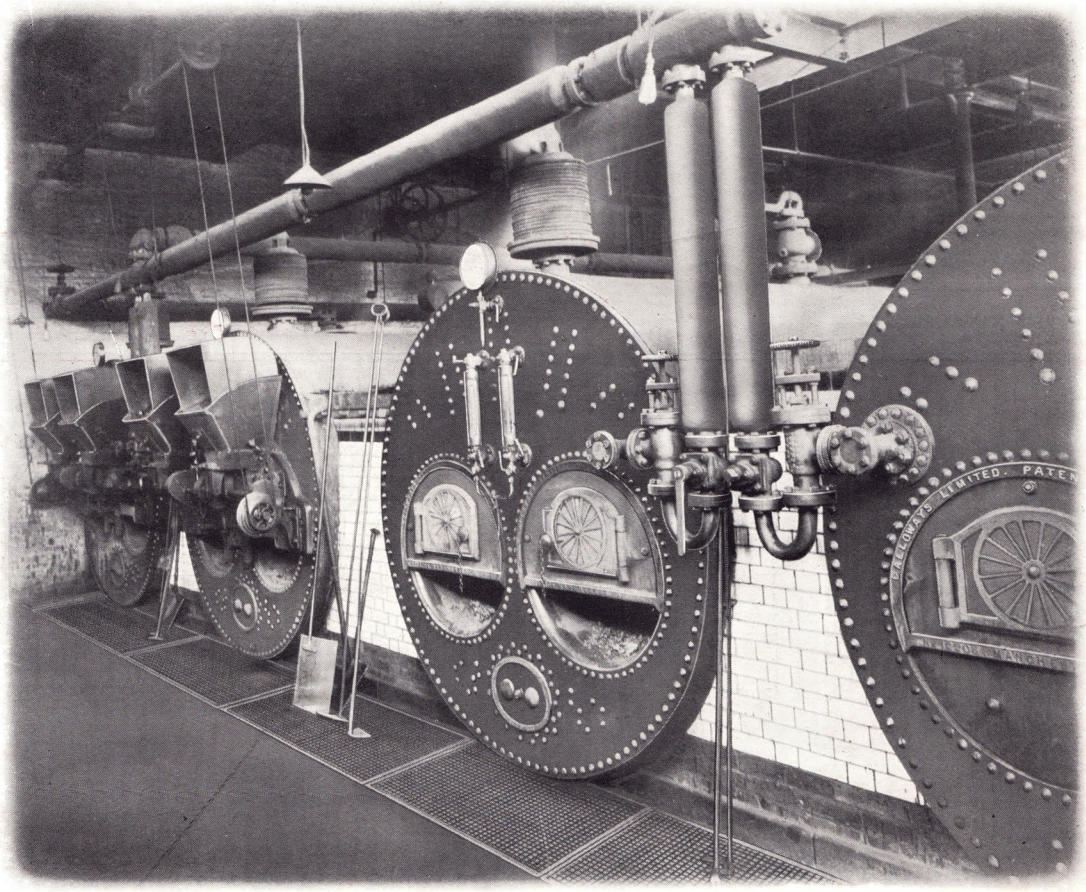
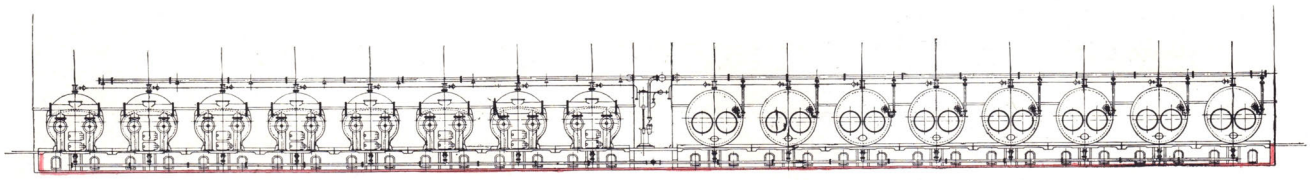


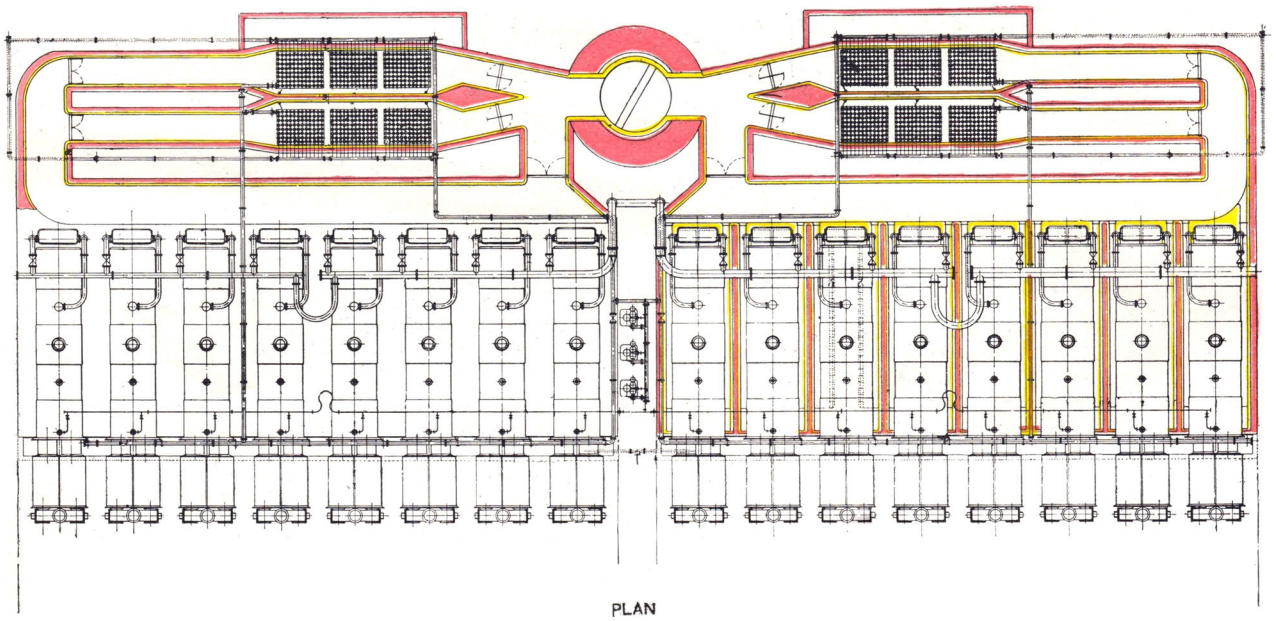
Fig. 4. Installation comprising four Lancashire Boilers, 30 ft. long, 8 ft. diameter, 165 lbs. per square inch working pressure.

Galloway and Lancashire Boilers have a large water space and therefore carry a large store of heat in the water. This enables them to meet fluctuating demands for steam with but a small variation in pressure.

The output of a boiler is determined by the weight of water which the boiler will evaporate to steam per hour. This depends on the grate area and the heating surface of the boiler. The Galloway Boiler has considerably more heating surface and better circulation than a Lancashire Boiler of equal size and will, therefore, evaporate more water for the same amount of coal burnt.



HALF FRONT ELEVATION SHEWING GAS PIPES AND COMBUSTION CHAMBERS — HALF FRONT ELEVATION WITH COMBUSTION CHAMBERS REMOVED



PLAN

Fig. 5. An installation of sixteen Lancashire Boilers is shown above. Each Boiler is 30 ft. long, 8 ft. diameter, and the working pressure is 160 lbs. per square inch.

Galloway Patent Superheaters are arranged in the rear of each Boiler.

These Boilers are equipped with extended furnaces suitable for a triplicate arrangement of firing.

They can be fired with coke oven gas, waste gas from underground flue and coal fired into ordinary grate.

In view of the fact that the Lancashire Boiler is in such common use, we might almost expect that standardization would have taken place and that there would be similarity in the finished product of different makers. The actual state of affairs is altogether different. Each firm has developed its own special construction by utilising its own experience and such casual information respecting the methods and procedure of rival firms as could possibly be obtained by the employment of new draughtsmen, foremen or workmen. It has been unavoidable under such circumstances that the rate of progress of different firms has varied. The strength of the technical staff, the method of acquiring and applying information received, the competency with which new and altered conditions, such as the great increase of boiler pressure which has taken place during the last thirty years has been met, the constant flow of suggestions and recommendations from the various Boiler Insurance Companies, the assiduity with which the

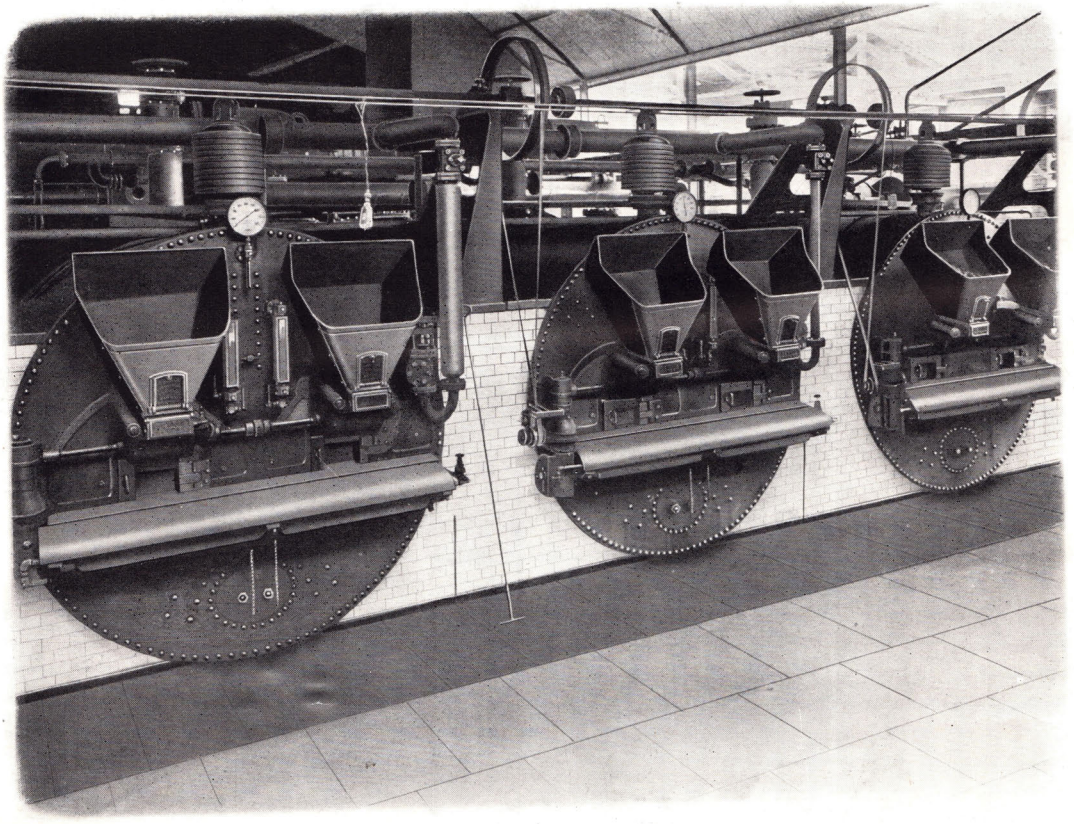


Fig. 6. Three Lancashire Boilers are here illustrated, size 30 ft. long by 8 ft. 6 in. diameter, 160 lbs. working pressure. The approximate steaming capacity of the installation is 24,000 lbs. per hour.

several Insurance Companies have desired boilermakers to incorporate their own favourite designs and specialities, have all been factors causing various makers to traverse different paths, with the inevitable result that though in external appearance all Lancashire Boilers are much alike, yet in reality very great differences indeed are to be found.

These considerations are important, we therefore proceed to explain in detail some of the principal points in modern Lancashire Boiler construction adopted by Galloways, Ltd., to ensure satisfactory boilers are produced.

The illustration, Fig. 8, shows an outside view of a standard Lancashire Boiler and Fig. 9, a longitudinal section. An external angle ring connects the flat end plate to the shell.

The Boilers are constructed with plain flanged flue tubes, and for very high pressures a length of corrugated flue is inserted, see Fig. 10. They are also made if specified with end plates dished and flanged as illustrated in Fig. 11 and Fig. 16, which comprises a battery of nine Lancashire Boilers 28 ft. long by 7 ft. 6 ins. diameter.

A Lancashire Boiler with the flat end-plate flanged outward for the flue connection is shown in Fig. 7.

The table on the opposite page gives particulars and sizes of standard Lancashire Boilers ; also rates of evaporation for various amounts of coal burnt per square foot of grate area.

The workmanship is of the very highest class and all plates used are carefully selected brands of Siemens-Martin open-hearth Mild Steel by the leading makers of the country. Every plate is tested, and certificates supplied if required.

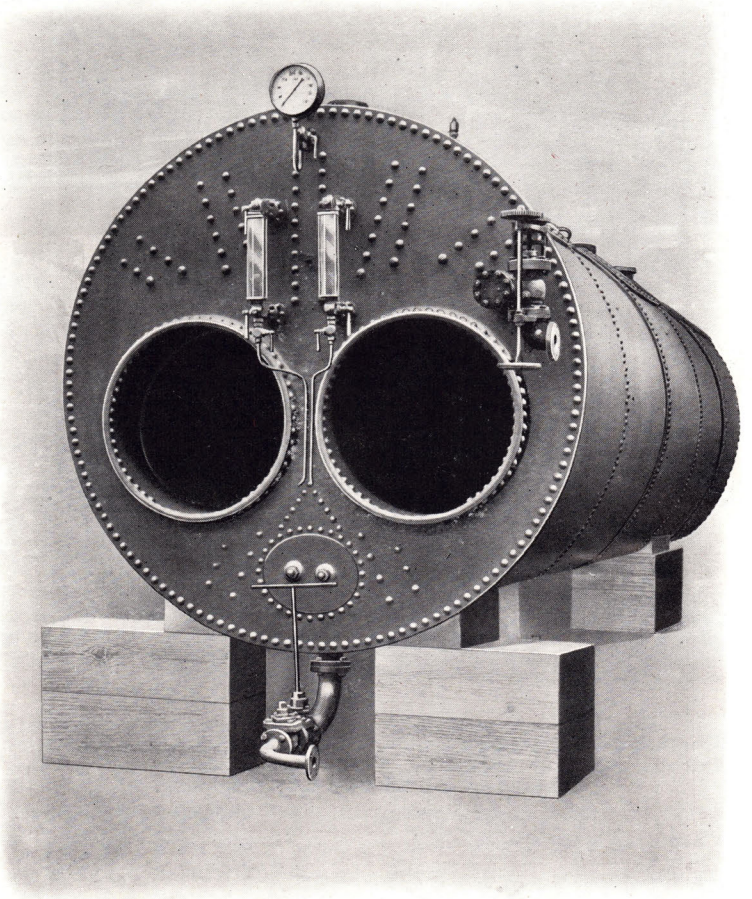


Fig. 7. One of three Lancashire Boilers with Flanged Flat End Plates, 30 ft. long, 8 ft. 6 in. diameter, 180 lbs. per square inch working pressure.

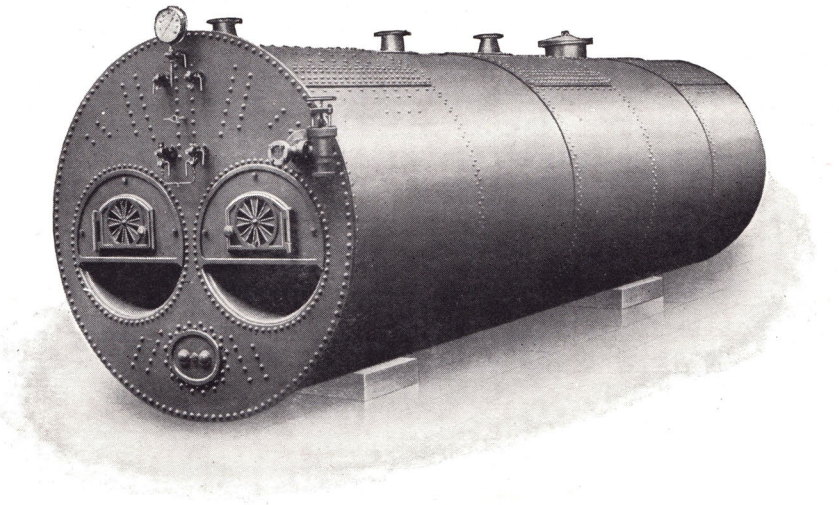


Fig. 8. Standard Lancashire Boiler with Flat End plates.

Standard "Lancashire" Boilers

No.	Size. Length X Diam.	Heating Surface.	Normal Grate Area	Outside Diam. of Flues	Steam Evaporated per Hour, Lbs. — Coal burnt per Sq. Ft. Grate per Hour			Approximate Net Weight — Working Pressure		Code Word
					20 lbs.	25 lbs.	30 lbs.	120 lbs.	160 lbs.	
	Ft. Ft. Ins.	Sq. Ft.	Sq. Ft.	Ft. Ins.	Lbs.	Lbs.	Lbs.	Tons.	Tons.	
1	14 × 5 6	290	14·5	2 1	2,300	2,900	3,500	6·5	7·5	Comet
2	16 × 5 6	340	16	2 1	2,500	3,200	3,800	7	8·3	Comfort
3	18 × 5 6	390	17·2	2 1	2,700	3,400	4,100	7·5	8·8	Comma
4	16 × 6 0	360	19·5	2 4	3,100	3,900	4,700	7·5	8·8	Commands
5	18 × 6 0	410	21	2 4	3,400	4,200	5,000	8·3	9·8	Commence
6	20 × 6 0	460	22·5	2 4	3,600	4,500	5,400	9	10·8	Comment
7	22 × 6 0	510	22·5	2 4	3,600	4,500	5,400	9·8	11·3	Commerce
8	20 × 6 6	520	23·2	2 7	3,700	4,600	5,600	9·8	11·8	Committee
9	22 × 6 6	570	25	2 7	4,000	5,000	6,000	10·3	12·3	Commode
10	24 × 6 6	620	27·5	2 7	4,400	5,500	6,600	11	13·5	Common
11	26 × 6 6	670	30	2 7	4,800	6,000	7,200	12	14·3	Compact
12	24 × 7 0	680	29·7	2 9	4,800	6,000	7,200	13·3	15·5	Companion
13	26 × 7 0	740	32	2 9	5,100	6,400	7,700	14·3	17·3	Company
14	28 × 7 0	800	32	2 9	5,100	6,400	7,700	15·5	18	Compass
15	30 × 7 0	860	32	2 9	5,100	6,400	7,700	16·5	19	Compeer
16	28 × 7 6	870	35	3 0	5,600	7,000	8,400	16·3	20	Compel
17	30 × 7 6	930	35	3 0	5,600	7,000	8,400	17·3	21·3	Compeller
18	28 × 8 0	930	38	3 3	6,100	7,600	9,100	18	23·3	Complain
19	30 × 8 0	1,000	38	3 3	6,100	7,600	9,100	19	24	Commune
20	30 × 8 6	1,050	40	3 5	6,400	8,000	9,600	21·5	26·3	Comrade
21	30 × 9 0	1,120	43	3 8	6,900	8,600	10,300	23·5	29·5	Comstock

BASIS.—8lbs. of water evaporated per lb. of coal. Boiler supplied with hot feed water as from a Green's economiser.

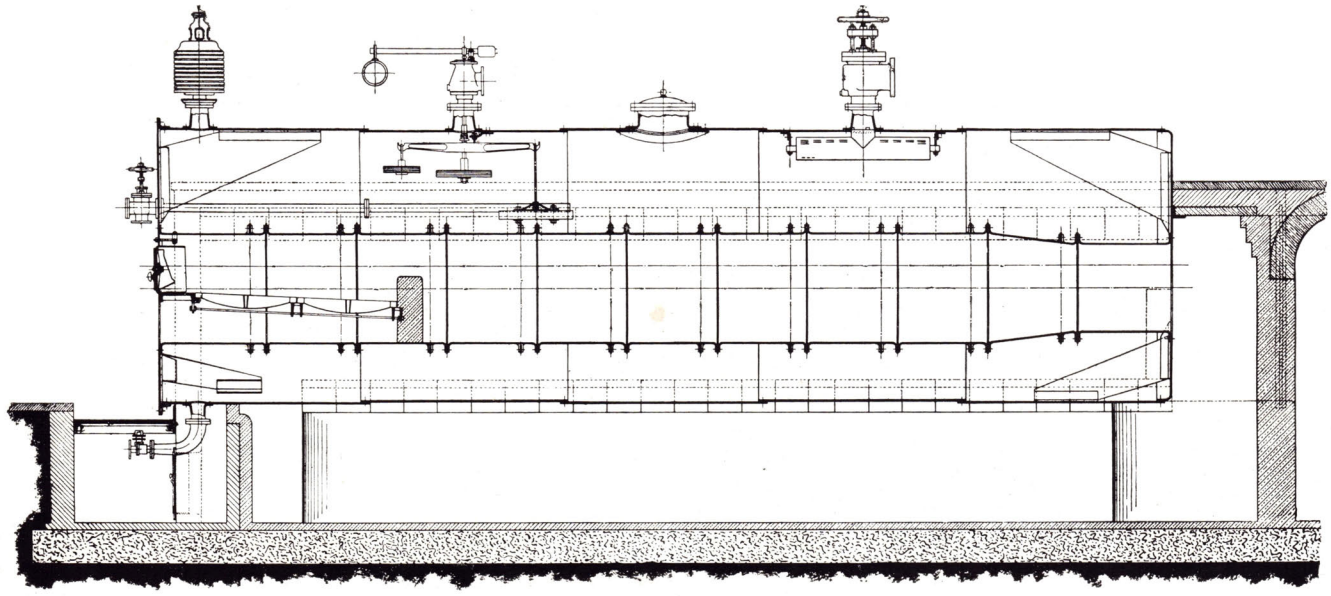


Fig. 9. Longitudinal section of Standard Lancashire Boiler showing Flat End construction and Gusset Stays.

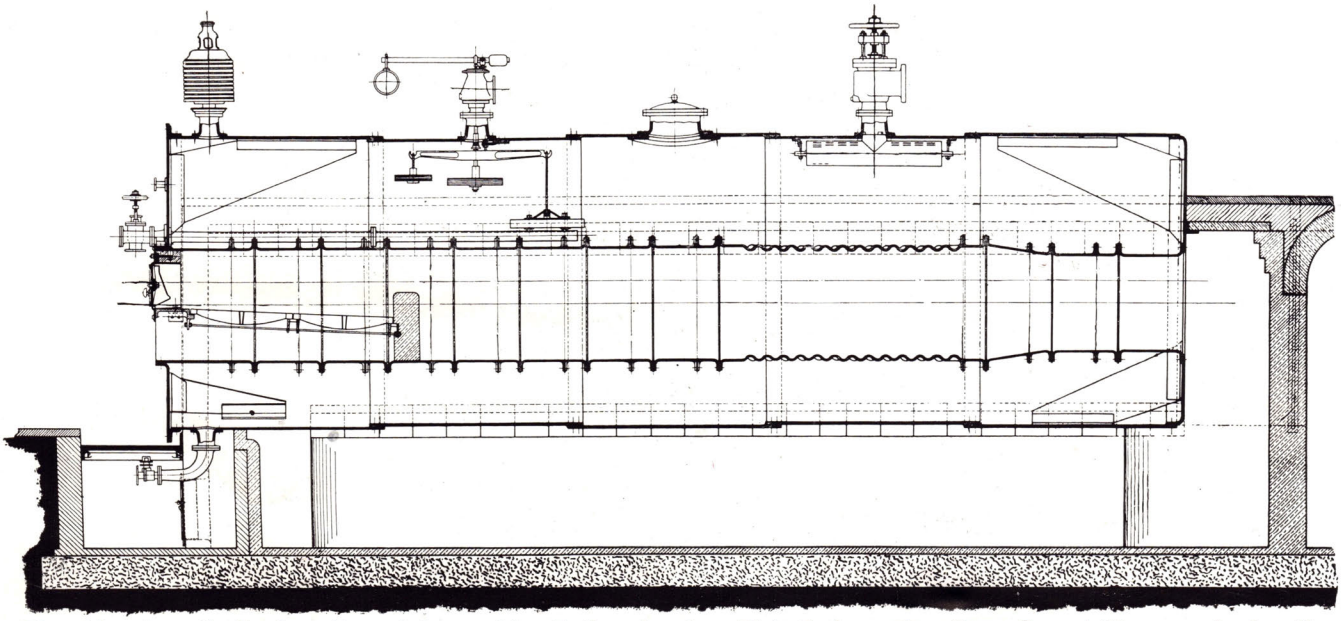


Fig. 10. Longitudinal section of Lancashire Boiler showing Flat End construction, Gusset Stays, and a length of corrugated flue tube at rear end to make further provision for expansion, usually adopted for higher pressures.

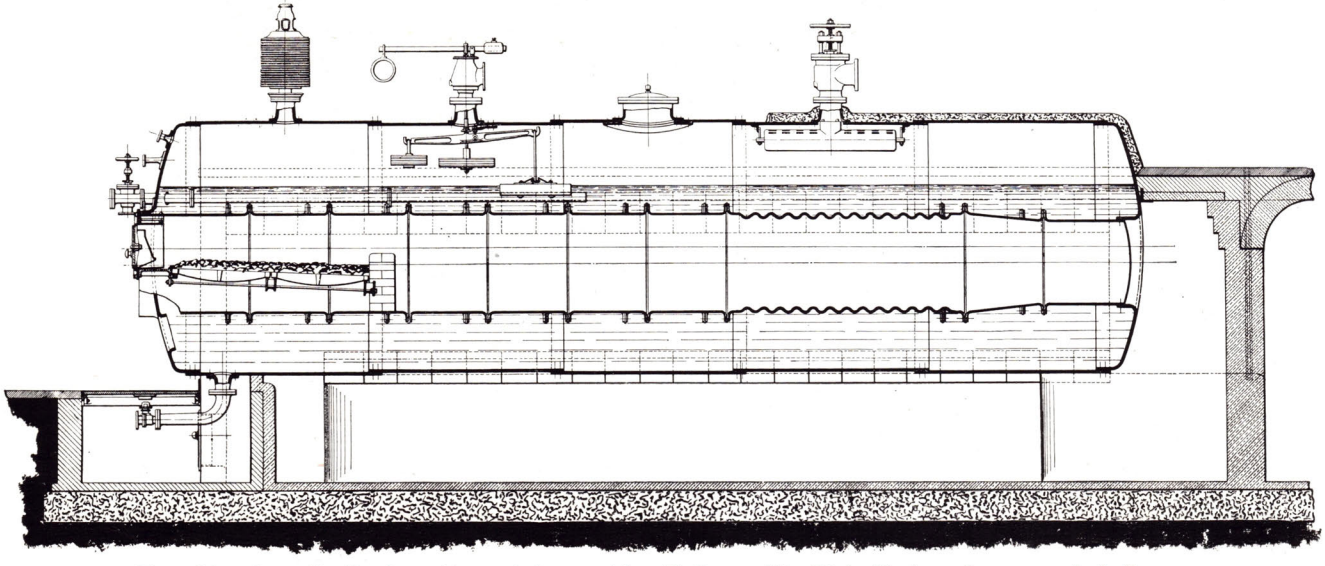


Fig. 11. Longitudinal section of Lancashire Boiler with Dish End and corrugated flues.

Boiler End Plates

The ordinary Lancashire Boiler consists of a cylindrical shell closed by flat ends and traversed by two circular fire tubes. The construction is of the simplest character and one which gives great natural strength except at the flat ends. Clearly an unsupported flat end construction is not well adapted to resist internal pressure. Many attempts have been made to modify this detail, and in the principal surviving variation there is used a curved plate commonly known as a dish end. With the flat end construction supplementary strengthening devices are necessary, these usually taking the form of gusset stays. With the dish end construction deflection is avoided and the necessary strength is obtained in quite a natural way without using any gusset stays. The general outlines of the two classes of boiler are shown in the illustrations, Figs. 9 and 11.

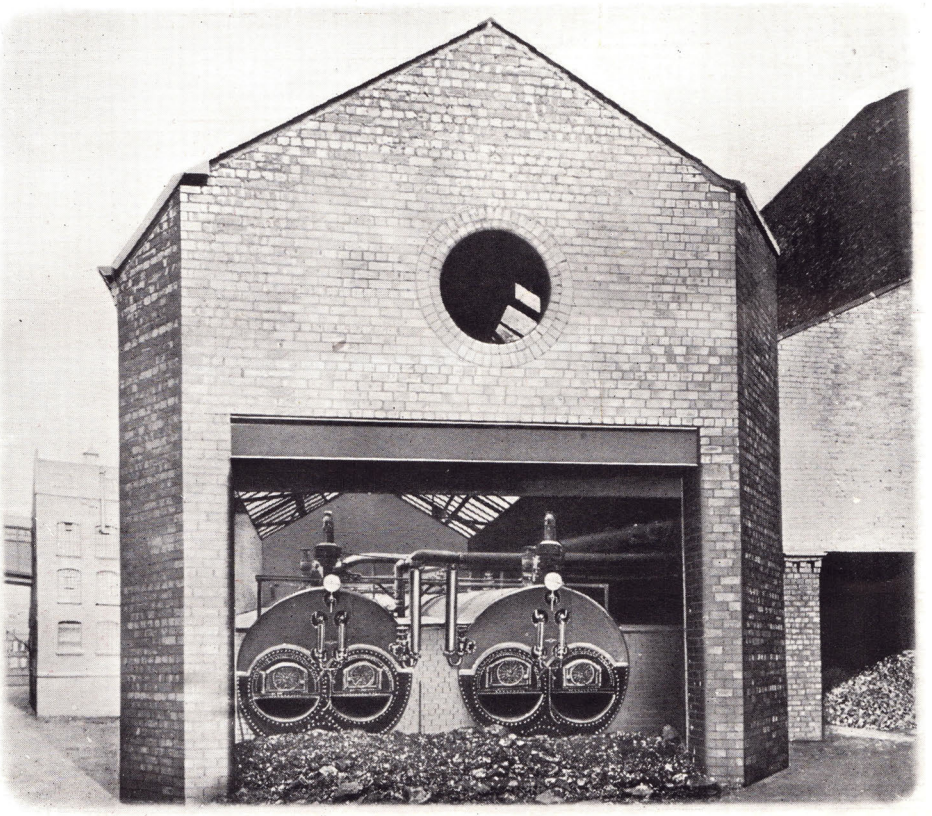


Fig. 12. Two Lancashire Boilers 30 ft. long, 8 ft. diameter, 160 lbs. working pressure. The foundations and buildings of this installation were constructed under the direct supervision of Galloways Limited.

At first sight the dish end construction appears to be the superior one, but in actual practice factors are found to exist which make it necessary to modify such an off-hand opinion.

Expansion and Contraction Arrangements

The great difficulty in the construction of a modern high-pressure boiler lies not at all in the arrangement of the various parts to withstand the desired boiler pressure, but in the arrangements of the parts to deal satisfactorily with the constant expansions or contractions, or both, which necessarily exist in a varying degree in all parts of the boiler. For example, a boiler thirty feet long, working at 160 lbs. pressure, is about three-quarters of an inch longer when hot than when cold. If the boiler is eight feet diameter it is about one-fifth of an inch larger in diameter when hot than when cold.

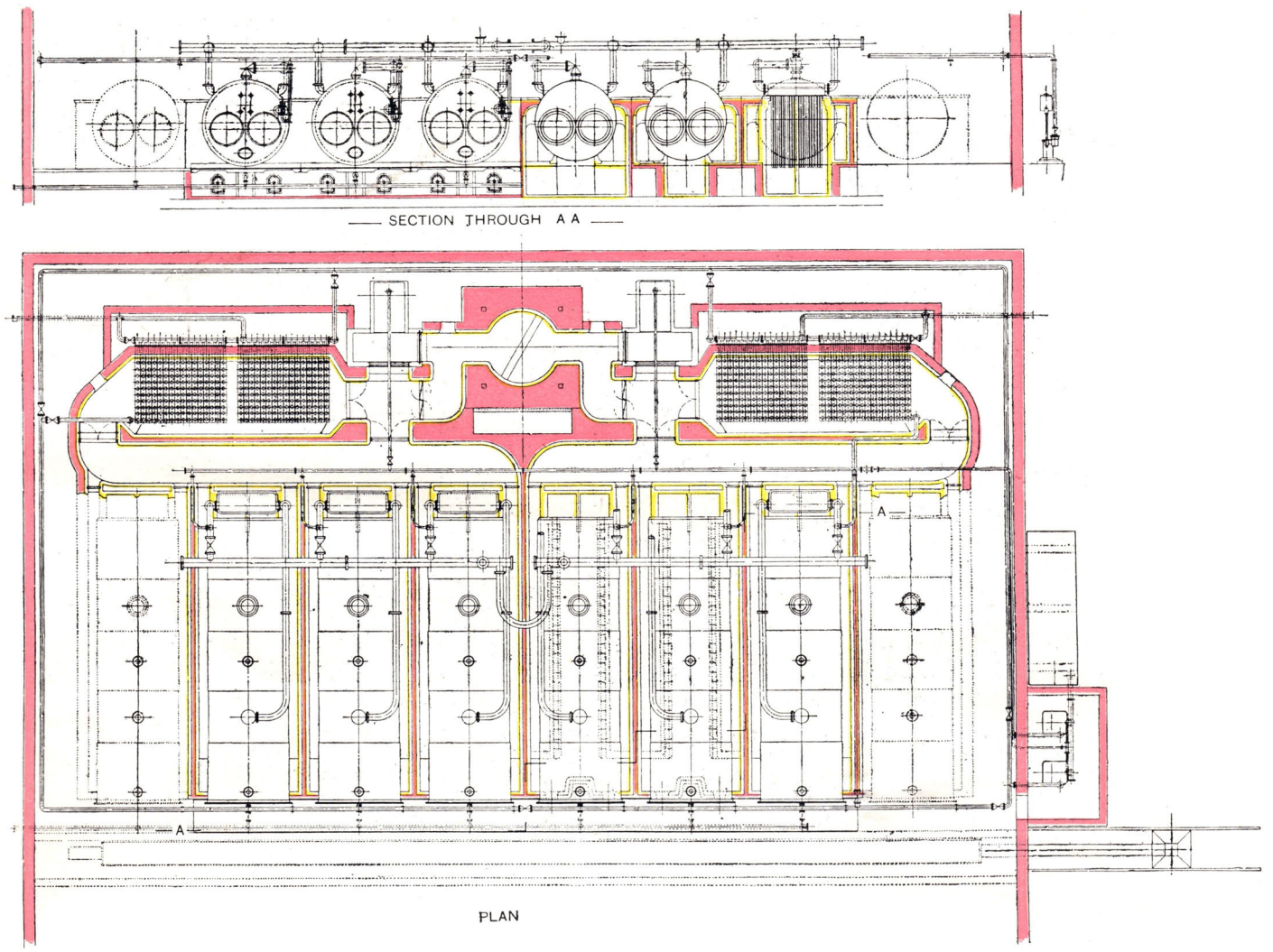


Fig. 13. An installation of six, with space allowed for eight, Lancashire Boilers, 30 ft. long and 8 ft. 6 in. diameter is shown in the above line drawing. This plant will generate about 48,000 lbs. of steam per hour. An induced draught fan is arranged in the flue and the flue gases discharge into a steel chimney.

Therefore, a boiler changes considerably in its linear dimensions while steam is being raised from cold water. It is also proved that owing to the presence of the fire in the two furnaces, the furnace tubes and flue tubes are hotter than the shell plates of the boiler. Theoretically the transmission of heat from the hot gases to the water in the boiler should proceed at such a rate as not to raise the temperature of the flue plates appreciably above the temperature of the water in the boiler. In actual practice, however, mainly due to the presence of steam bubbles and deposit on the water side of the plate, the flue tube does become " overheated " with the general result that the flue tube elongates more than the shell plates. The difference between the two is frequently as much as a quarter of an inch, and in such cases the shell would elongate three-quarters of an inch and the flue tube would elongate one inch. Again, the amount of

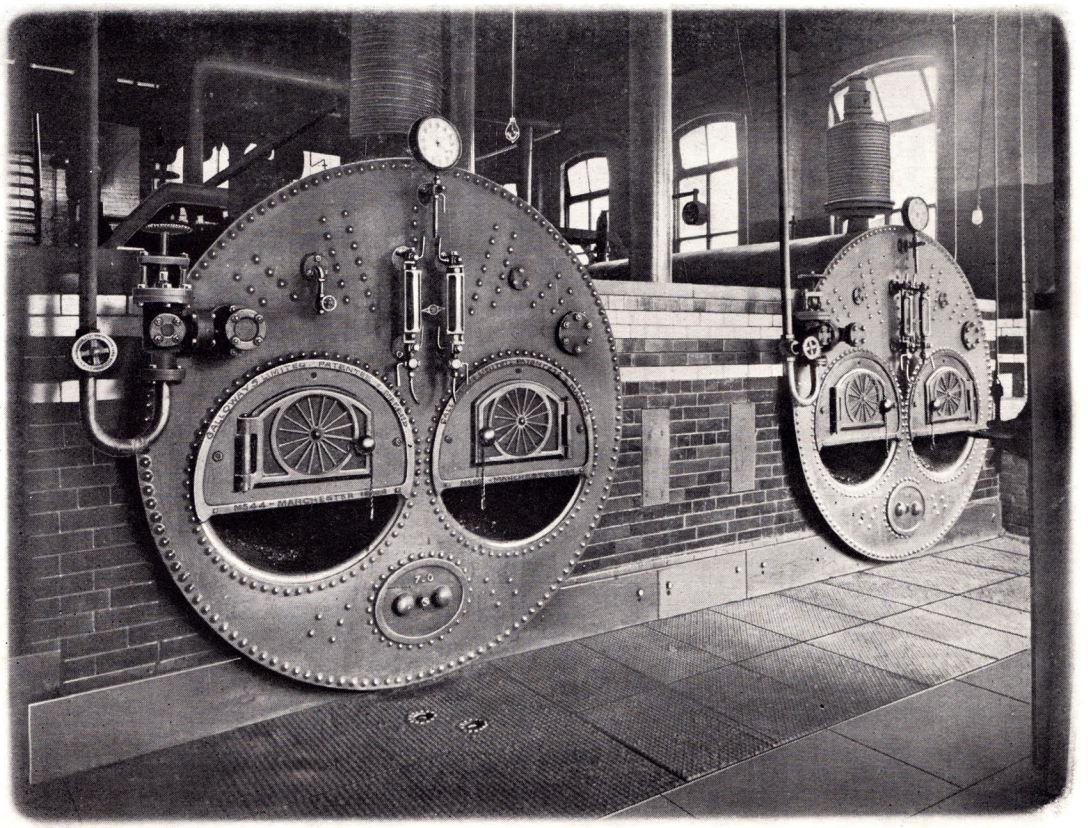


Fig. 14. Two Lancashire Boilers, 30 ft. long, 7 ft. 6 in. diameter, 100 lbs. working pressure, for Municipal Baths.

expansion of the flue tube varies according to the temperature of the fire. The flue tube is at maximum length when the fire doors have been closed for some time on a good fire. The flue tube is at its shortest after " clinkering " and with the fires made up with green coal.

The " Hogging " of Flue Tubes

Another factor to be taken into account is that the flue tubes are hottest on the upper side, the increase of temperature being greatest in that part of the furnace tube over the fire and the firebridge. Consequently the upper side of the furnace tube lengthens more than the lower side. This results in a curvature of the flue tube. The term " hogging " is usually applied to this alteration of shape, the " hogging " taking place in an upward direction.

Makers of the flat end type of boiler affirm that the best plan is to make provision for expansion and contraction at the ends of the flue tube by arranging a flexible end plate in such

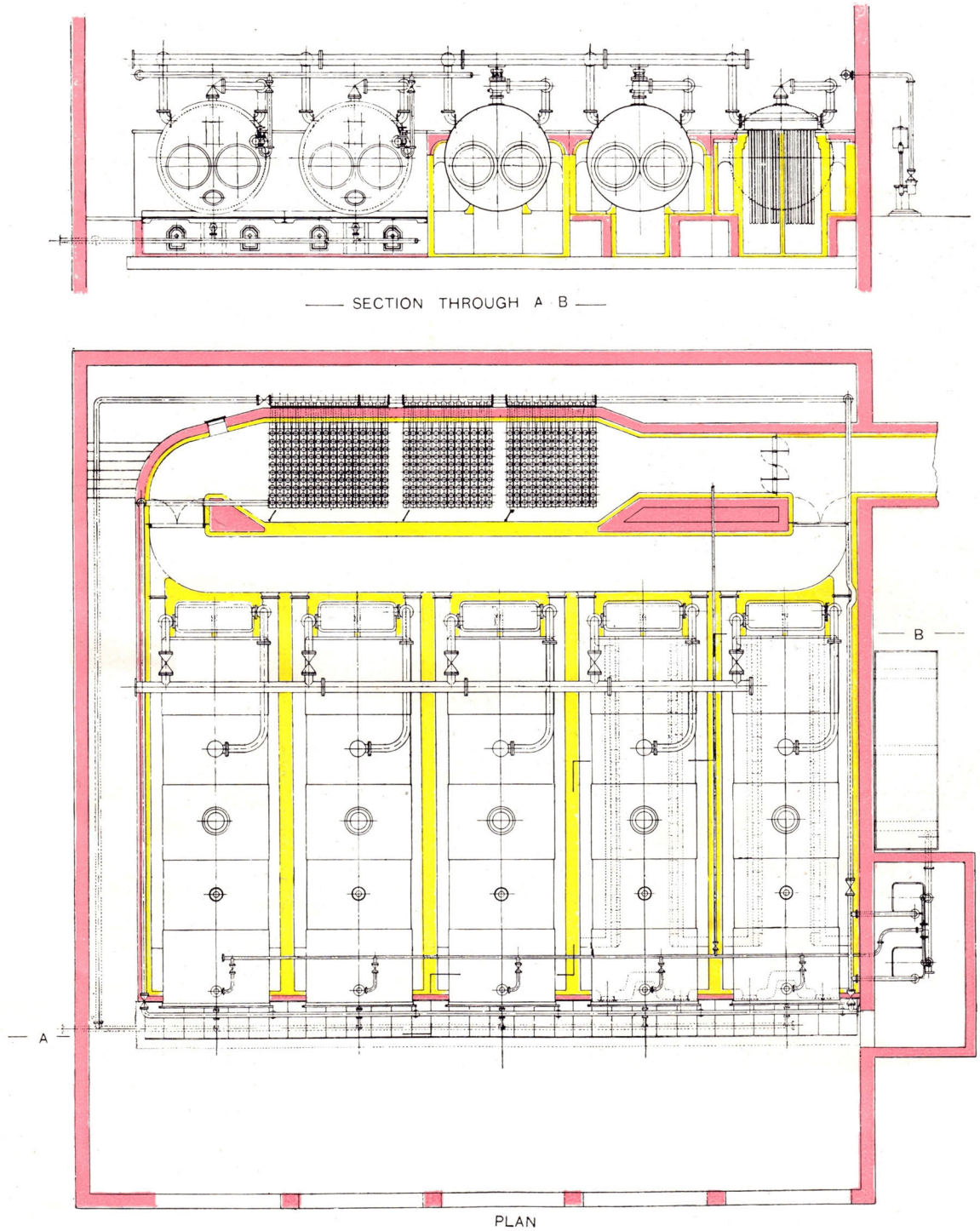


Fig. 15. The above illustration shows a plant comprising five Lancashire Boilers, 30 ft. long and 8 ft. 6 in. diameter, 160 lbs. per square inch working pressure. A Galloway Patent Double-Header Superheater of wrought steel throughout is placed in the downtake flue at the back end of each Boiler.

The approximate steaming capacity of the installation shown above is 40,000 lbs. steam per hour.

a manner that the repeated movement is provided for without causing undue straining on any part of the end plate or flue tube. Dish end boilermakers, on the other hand, not being able to tackle the problem in this particular way owing to the extreme rigidity, indeed immovability, of the dish ends, make provision in the flue tube itself for the unavoidable expansion and contraction. This provision usually takes the form of a corrugated flue tube arranged in part of the length of the boiler, or arranged the full length of the boiler according to circumstances, see figs. 11 and 16. Thus the ordinary Lancashire Boiler relies for adequate " breathing space "

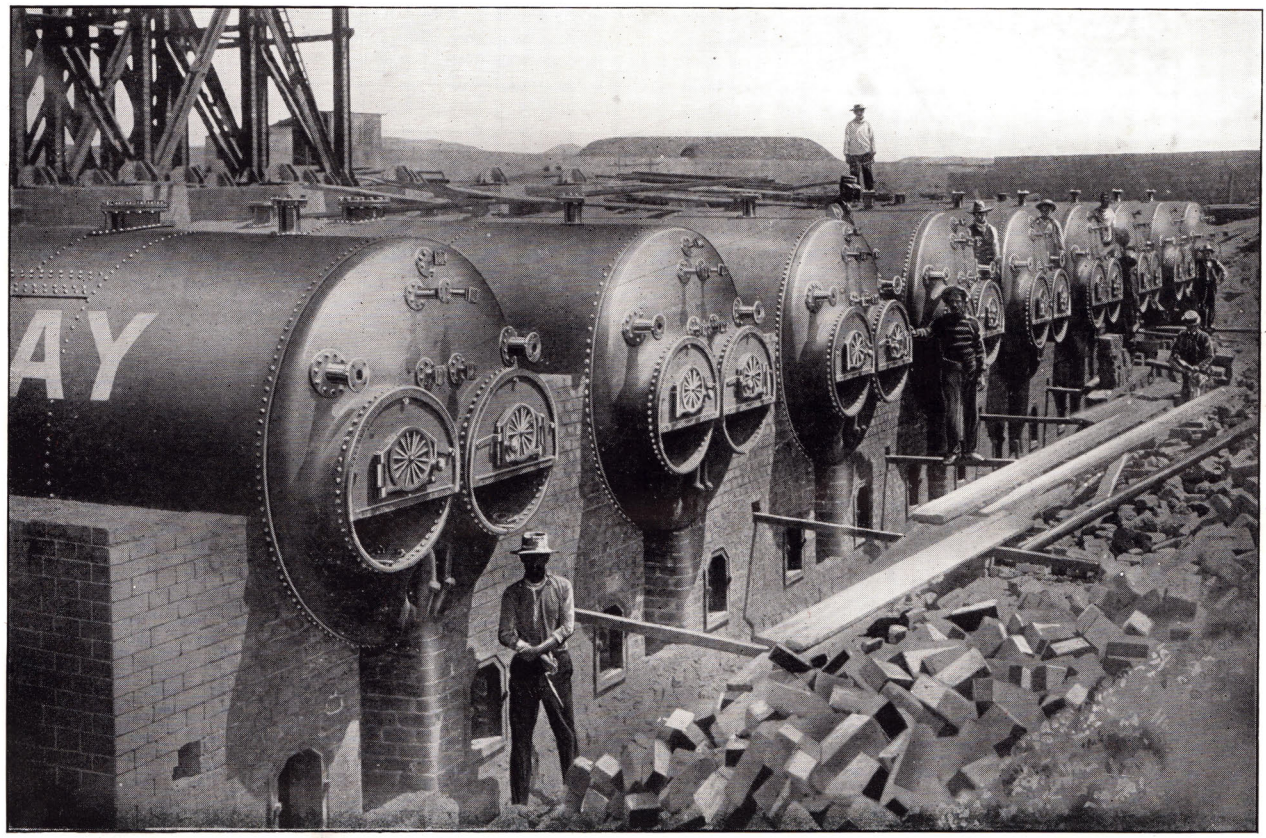


Fig. 16. Group of Galloways Improved Dish-End Boilers, with Flanged Connections for Flues and Mudhole Opening.

on the flat end plates, and the dish end boiler relies on the " concertina " action of the flue tube itself. There is a fundamental difference between these two methods. In the former case the expansion and contraction goes on without causing any straining on the flue tube itself. In the latter case the movements of expansion and contraction are forcibly restrained by the rigid dish end plates and are taken up at the tube corrugations.

The flat end boiler for high pressures is entirely satisfactory due to provision of increased flexibility in the flat ends ; and the dish end boiler in its turn finding plain flue tubes altogether too stiff, has been made a serviceable type by the use of corrugated flue tubes. In each case good results can now be obtained, but in view of the facts that repairs can be usually much more easily and cheaply executed on flat end boilers than on dish end boilers, that the dish end boiler occupying any given ground space loses a considerable amount of heating surface owing to the shorter boiler shell, and that corrugated flue tubes require special fire bars and are awkward to clean, both on the fire and water side, the majority of purchasers usually decide to adopt a good type of flat end construction.

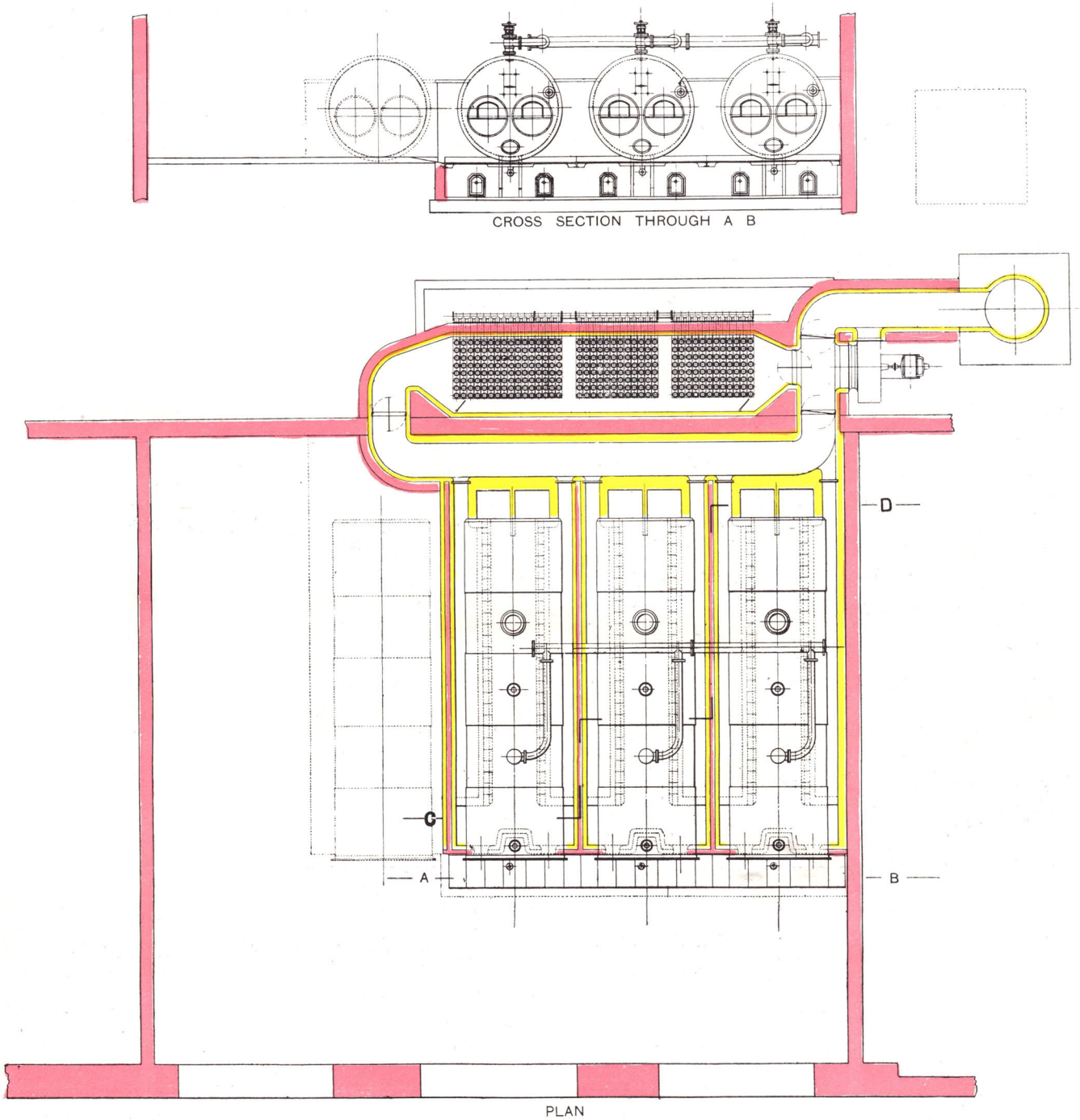


Fig. 17. An installation of three Lancashire Boilers, 30 ft. long and 8 ft. 6 in. diameter, 160 lbs. per square inch working pressure, is shown in above figure. Space is provided in the Boiler House for the addition of another boiler as the plant extends.

An induced draught fan, motor driven, is arranged in the flues, which are constructed so that the Boiler can be worked with or without induced draught.

The installation is provided with a steel chimney.

This plant will generate approximately 24,000 lbs. of steam per hour under satisfactory conditions.

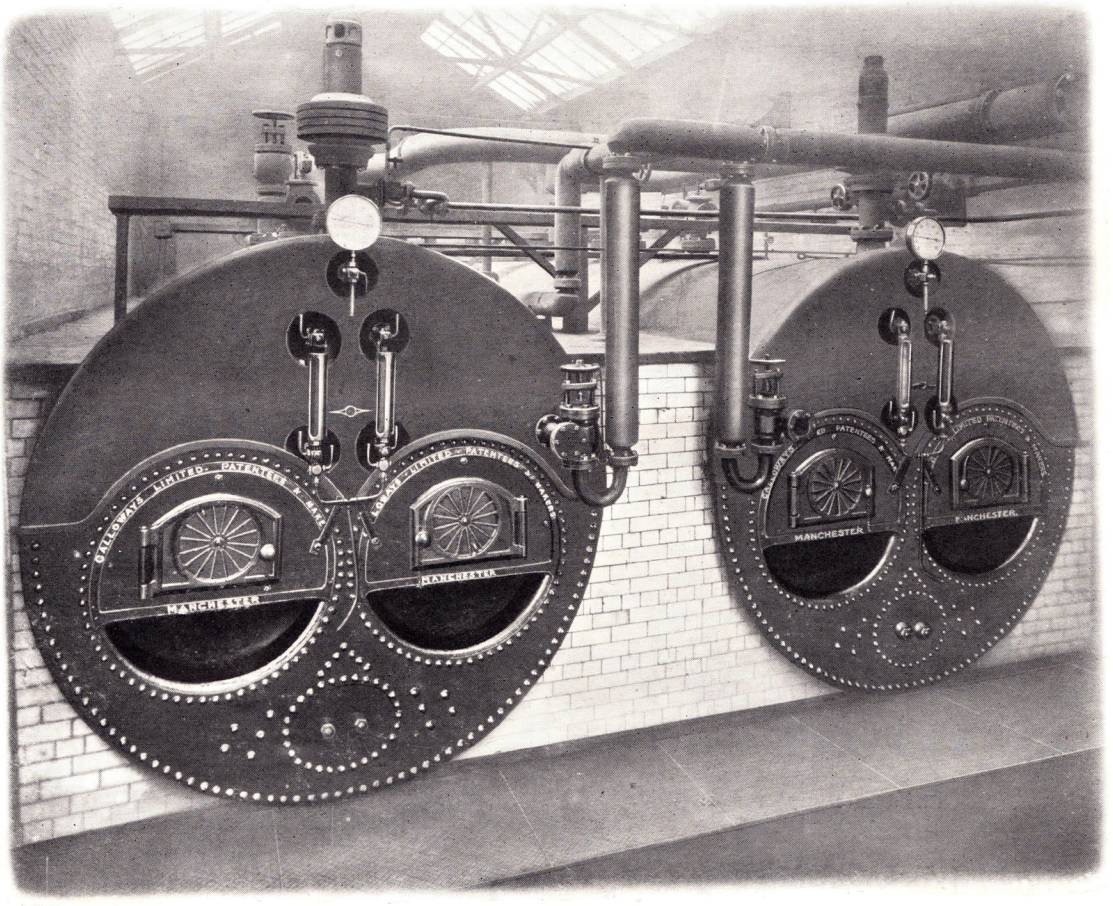


Fig. 18. The above illustration gives a view of the Boiler fronts of the installation shown in Fig. 12.

The actual means adopted by Galloways, Ltd., to secure flexibility of flat end plates are summarised as follows :—

Firstly, the provision of adequate breathing space over the flue tube.

Secondly, the avoidance of unduly thick stiff end plates.

Thirdly, the provision of an adequate number of gusset stays to suit the desired thickness of end plate.

Fourthly, the use of large gusset angles in order to further facilitate the satisfactory use of the selected end plate.

Fifthly, a special arrangement of the rivets in the gusset angle and gusset plate, whereby the lower rivets are placed in single shear and only the upper rivets in double shear.

The sketches, Figs. 19 and 20, embody these principles as applied to the staying of a large boiler.

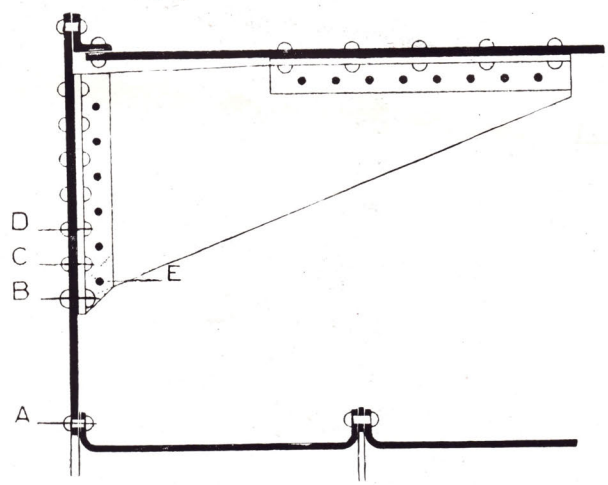


Fig. 19. The Galloway Gusset Stay.

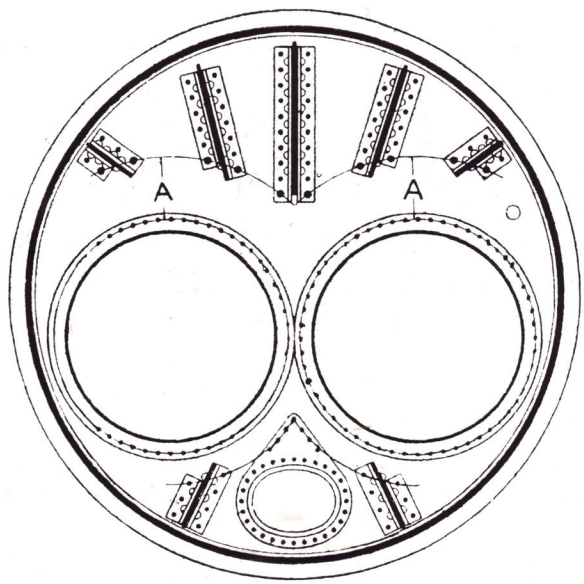


Fig. 20. Galloway Standard Boiler Staying for large boilers.

Design and Workmanship

In addition to the excellent design, the workmanship receives careful attention as follows :

(*a*) The end plate is made perfectly flat in the first instance.

(*b*) The various gusset stays and the flue tubes are made exactly of the right length, the greatest care being taken to ensure that none are too long when the end plate is rivetted on, otherwise undue initial stresses would be generated in the end plate.

(*c*) The rivet holes are made perfectly fair with each other, the rivets are an excellent fit in the rivet holes, and the rivets are closed by heavy hydraulic pressure.

(*d*) The lowest rivets near the flue tube, which have the greatest load to bear are of greater diameter than the rivets further up the gusset stays which have the lesser load to bear.

These methods have in recent years received a most thorough testing and it is now possible to say with confidence, on the assumption that the boilers are worked under reasonable conditions, without excess of deposit and without grease in the boilers, that freedom from leakages and premature grooving is ensured.

Grooving

Obviously the first duty of an owner to his boiler is to provide satisfactory feed water and systematic internal and external cleanliness of the heat transmitting surfaces. Heavy hard deposit or the even more dangerous light floury magnesia deposits or greasy feed water should on no account be permitted, otherwise severe damage may be done to perfectly new boilers. In order to make clear the exact nature of " grooving " and the necessity for proper care in working the boiler the following explanation is given.

" Grooving " is mechanical in origin and arises :—

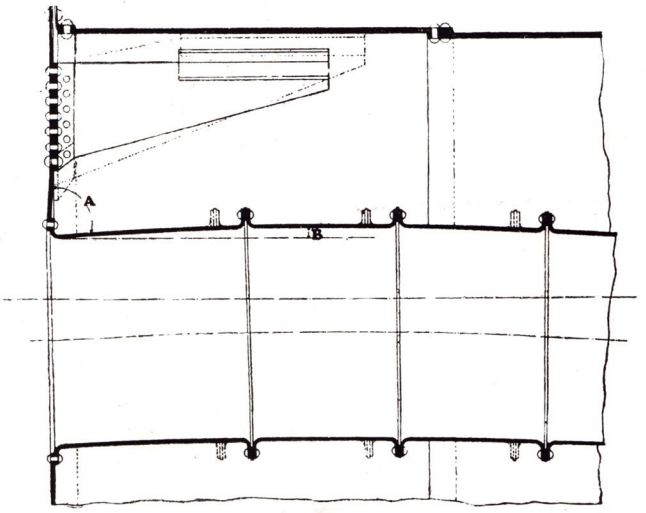


Fig. 21. Hogging and Curvature of End Plate.

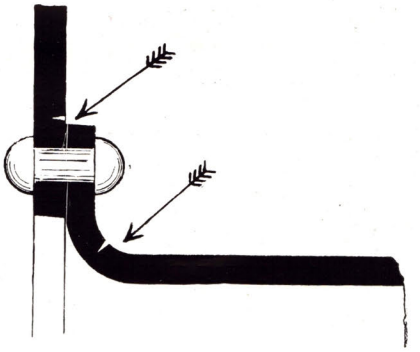


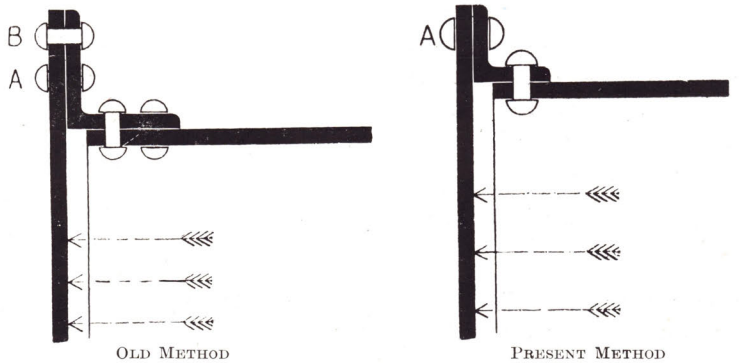
Fig. 22. Grooving.

Firstly, from the expansion of the flue tube.

Secondly, from the Hogging of the flue tube causing the angle marked "A" on the illustration, Fig. 21, to vary from a right angle when the boiler is at rest, to something less than a right angle when the boiler is at work.

These movements necessarily mean mechanical stress, and undue mechanical stress means loosening of the fibres, fracture, and eventually the well-known form of deterioration known as grooving.

On the drawing, Fig. 22, the defect is shown diagramatically in such a manner to make the nature of this defect understandable even by those who have so far been fortunate to escape direct contact with this most annoying trouble. Note the cracks or " grooves " at the root of the flange and above the rivet on the end plate.



OLD METHOD — PRESENT METHOD

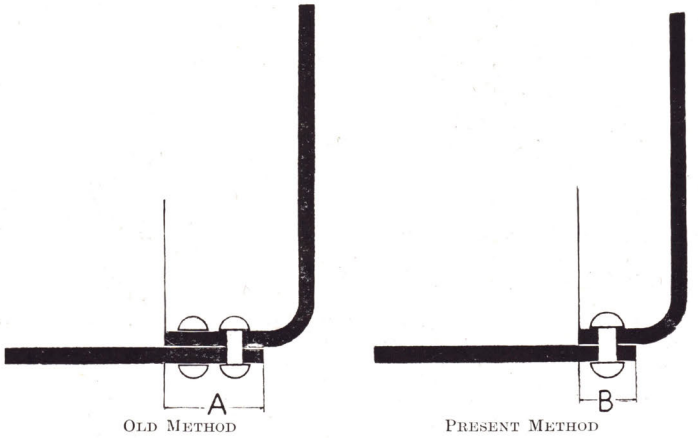
Double Riveting. **Fig. 23.** **Single Riveting.**

End Plate Riveting

Attention may now usefully be directed to two important features of construction adopted in Galloways' standard practice by means of which certain causes of leakages on the back and front end plates have been completely removed. Both these special features refer to the method of securing the back and front end plates to the shell plates. It was formerly the practice to rivet the back end plate to the shell, and the front end plate to its angle ring, and this ring to the shell by means of double riveting, see Fig. 23. The present construction utilises single riveting only and thereby obtains certain advantages as follows :—

In the case where the front end plate is double-riveted to the shell angle there is quite a deceptive appearance of strength given by the two rows of rivets. The general impression formed on first inspection is almost invariably that the steam load on the front end plate (shown by the arrows), is borne by both rows of rivets. But a careful consideration will show that it is impossible for the outer row of rivets to take any load unless the inner row of rivets is first stretched a little. This is clearly proved by the fact that in a double riveted end plate the inner row of rivets always leaks first, and this can only be caused by this row attempting to take the whole steam load. The remedy is to replace the two rows of rivets by a single row with the rivets made of considerably larger diameter. In this way an equal factor of safety can be readily obtained and leakages are entirely prevented in view of the increased strength and grip per rivet. As regards the riveting of the angle to the shell, and the riveting of the back end plate to the shell such double riveting is not necessary as a mere matter of strength owing to the greater portion of the end plate load being taken up on the gusset stays. On this negative account alone the expense of double riveting is unnecessary, but on the back end plate there is an important positive reason why single riveting is markedly better than double riveting. This is clearly brought out on the two sketches, Fig. 24.

Attention is directed to the difference in the amount of overlap of the plates. In the case of the double riveting, with the longer overlap, all heat absorbed by the shell plate from the passing flue gases, which are probably at a temperature corresponding to a dull red heat, has to pass along the shell plate, through the distance (A), before it is transferred to the water inside the boiler. In the case of the single riveted construction the distance (B), is very much less, consequently the liability to overheating of the shell plate in the second case is diminished. In actual practice it is found that the former construction frequently gives rise to a leakage at the caulked seam between the end plate and the shell. In the latter construction such leakages, assuming reasonable workmanship, never occur.



OLD METHOD — PRESENT METHOD

Fig. 24. Back End Plate Riveting.

Riveting

The whole of the riveting, so far as is practicable, is performed by modern hydraulic riveting machines. All holes for rivets having been previously drilled and countersunk to remove burrs in order to add to the strength of the rivet heads.

Rules for working Boilers

Feed Water

(*a*) Use feed water of good quality which does not give heavy scale.

(*b*) Avoid feed water giving light floury magnesia deposits. Chemical treatment should be effected outside the boiler, not inside.

(*c*) On no account use feed water which contains grease or oil.

(*d*) The blow-off valve should be opened once daily and more frequently if the water contains soluble salts. Be sure the blow-off valves of other Boilers in the range and out of commission are closed, before opening the blow-off valve of a working boiler.

(*e*) The check feed valve should be adjusted so as to feed continuously and maintain a constant water level. All the water gauge cocks to be tested frequently when the boiler is working.

Safety Valves

See that the dead-weight safety valve and the high steam and low water safety valve are free and in working order ; test both daily.

Never interfere with the loading without permission.

Pressure Gauge

Keep the gauge syphon clean. Before attaching the gauge fill the syphon with water.

Getting up Steam

Never do this hurriedly when starting up. The superheater (if any) should be in communication with the Boiler.

Firing

Fire steadily and avoid rapid fluctuations of pressure.

One side of each furnace should be fired at a time, keeping the bars covered with live and even fire.

After firing admit air through the star plate in the fire door.

Do not check steam by leaving the fire doors open. Cold rushes of air adversely affect the flues.

Steam Pipes and Valves

Before opening any steam valve, care should be taken to ensure that all water has been drained from the steam pipes.

Shortness of Water

It is difficult to advise what course of action to take in the event of this crisis owing to the varying conditions. The attendant should use his own judgment. Usually close the dampers, open the furnace doors, smother the fires and open the feed valve. The fire should not be broken up or withdrawn until all danger is passed.

Explosions in Flues

To avoid gas explosions in the flues, always open the dampers wide before lighting or breaking up the fire.

Cleaning

The Boiler should be emptied and allowed to cool as gradually as possible.

Clean the Boiler internally at frequent intervals, according to the quality of feed water used.

The flues and outside of plates should be swept clean and all brickwork maintained in good condition and air-tight.

Keep the boiler fittings clean, and thoroughly examine and overhaul if necessary each time the Boiler is cleaned. *See Galloway's Boiler Fitting Catalogue.*

Inspection

The Factory and Workshop Acts of 1901 and 1907 also the Coal Mines Act of 1911, compel users to have Boilers thoroughly examined by a competent person at least every fourteen months.

The Coal Mines Act of 1911 section 56 also states that Boilers after being cleaned must be examined internally, as far as the construction of the Boiler will permit, by the person in charge of it once at least in every three months.

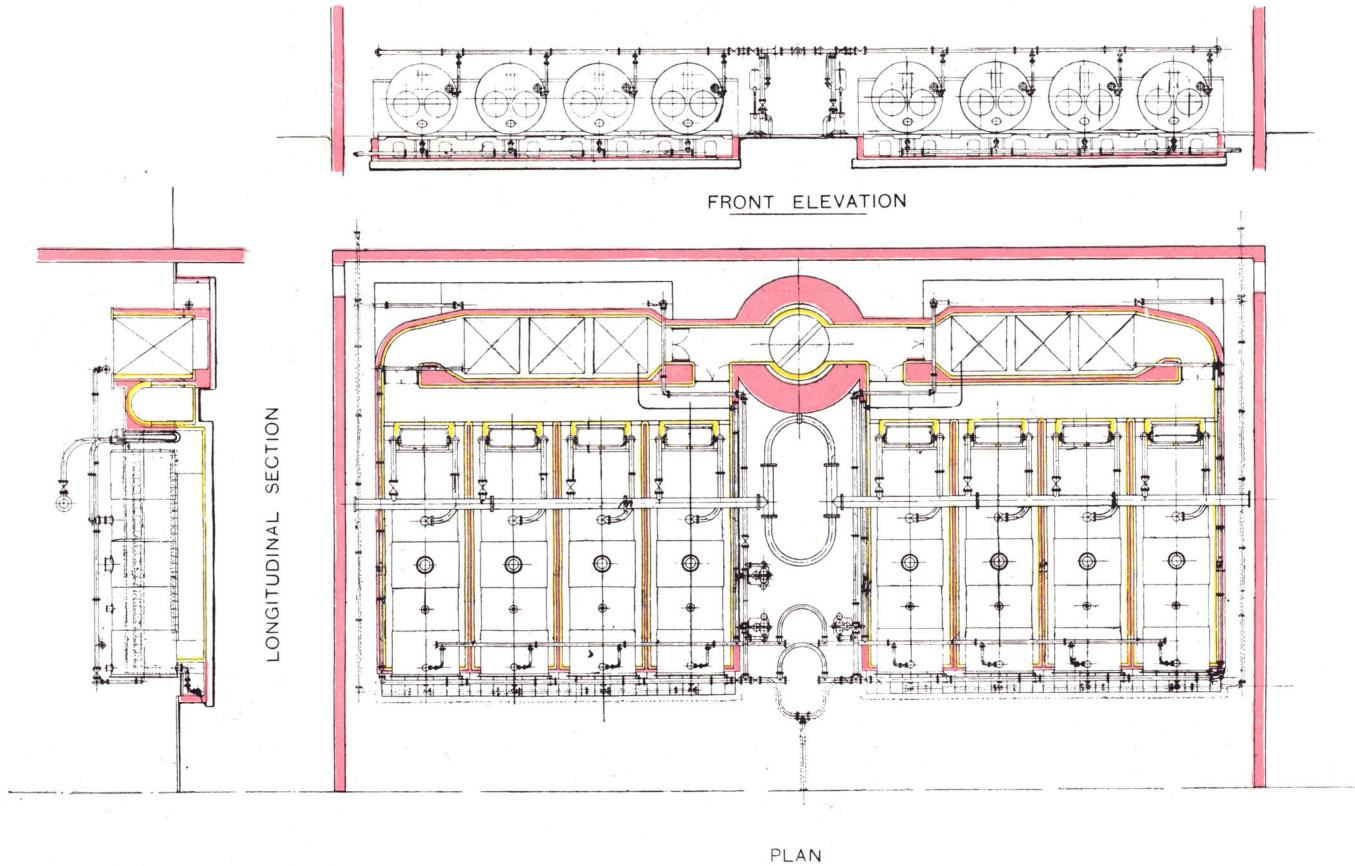


Fig. 25. On this page is shown an installation comprising eight Galloway Boilers, 30 ft. long, 8 ft. 6 in. diameter, designed for 160 lbs. per square inch working pressure, arranged in two batteries working into the same chimney.

This plant will evaporate 64,000 lbs. of water per hour under average conditions.

The plant can be doubled by arranging boilers on the other side of the common stoke hole.

Notes on Oil Burning using Galloway Burners

Boilers may be fitted with one, two or four burners as required according to the size of the boiler and the evaporative duty required.

The comfortable working capacity of each burner is from 11 to 25 gallons of oil per hour (100 to 225 lbs.). This is equivalent to 150/340 lbs. coal per hour on the average values of 18,000 B.T.U.'s per lb. oil, and 12,000 B.T.U.'s per lb. coal.

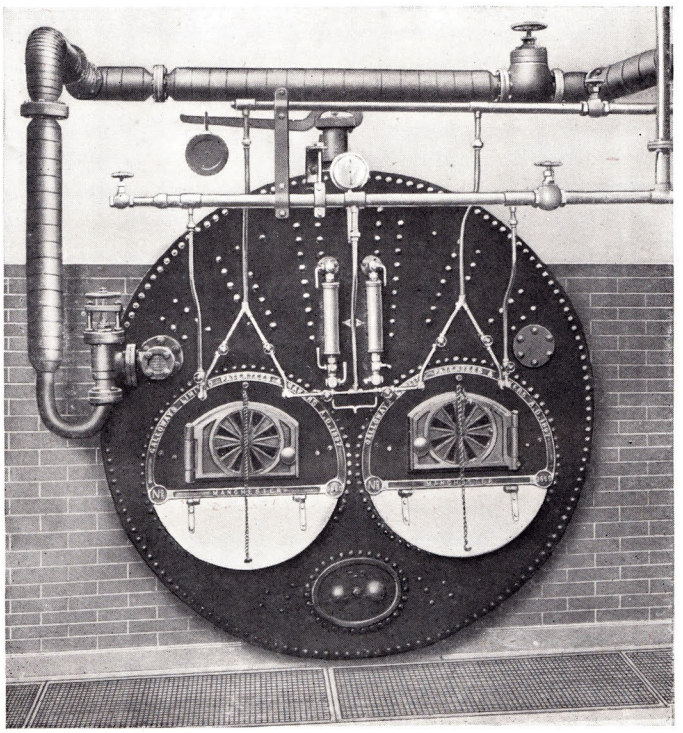


Fig. 26. Lancashire Boiler with Auxiliary Galloway Oil Burners.

Expressed in terms of coal the relative value of the burners is approximately as follows :—

	Minimum.		Maximum.
1 Burner	- $1\frac{1}{3}$ cwts. coal per hour	-	3 cwts. coal per hour.
2 Burners	- $2\frac{2}{3}$,, ,, ,,	-	6 ,, ,, ,,
4 Burners	- $5\frac{1}{3}$,, ,, ,,	-	12 ,, ,, ,,

Expressed in terms of steam raising capacity and on the assumption that the boiler plant efficiency (boiler and economiser) is about 70% the steam production is as follows :—

	Minimum.		Maximum.
1 Burner	- 1,150 lbs. steam per hour	-	2,600 lbs. steam per hour.
2 Burners	- 2,300 ,, ,, ,,	-	5,200 ,, ,, ,,
4 Burners	- 4,600 ,, ,, ,,	-	10,400 ,, ,, ,,

As a rule the number of burners required may be checked from the following table :—

Cornish Boiler up to 5 ft. diam. 1 Burner. Lancashire Boilers up to 6 ft. 6 in. diam. 2 Burners.
,, ,, over ,, ,, 2 Burners. ,, ,, over ,, ,, 4 Burners.

The steam used by the jets is small and varies from 3% to 5% of the steam produced, according to circumstances.

A storage tank on ground level should be provided to receive the oil from oil tank cars, or barrels as the case may be. The oil is then lifted from the storage tank to an overhead tank by means of a small steam pump or other type of pump.

The overhead service tank should be fixed with the bottom approximately 18 in. to 24 in. above the top of the boiler. It is of the highest importance that the service tank should be provided with a steam heating coil to raise the oil to a temperature of about 120° F. The oil flows by gravity from the service tank to the burners and can be finely regulated by means of the cocks.

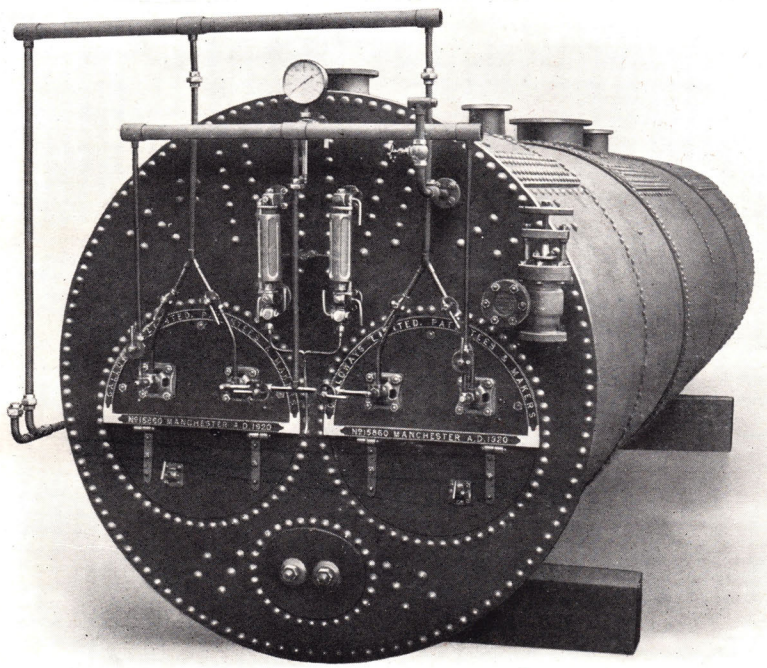


Fig. 27. Lancashire Boiler fitted with permanent Oil Burning Equipment.

Steam for atomising the oil should be taken from a point on the boiler as high as possible, or any convenient steam pipe. This steam must be dry and preferably superheated. To effect this we recommend fixing a horizontal loop pipe in the side flue passing in and out through the front brickwork of the boiler (see illustration). From the U loop the steam passes to an overhead pipe with branch connections to burners as shown in illustrations.

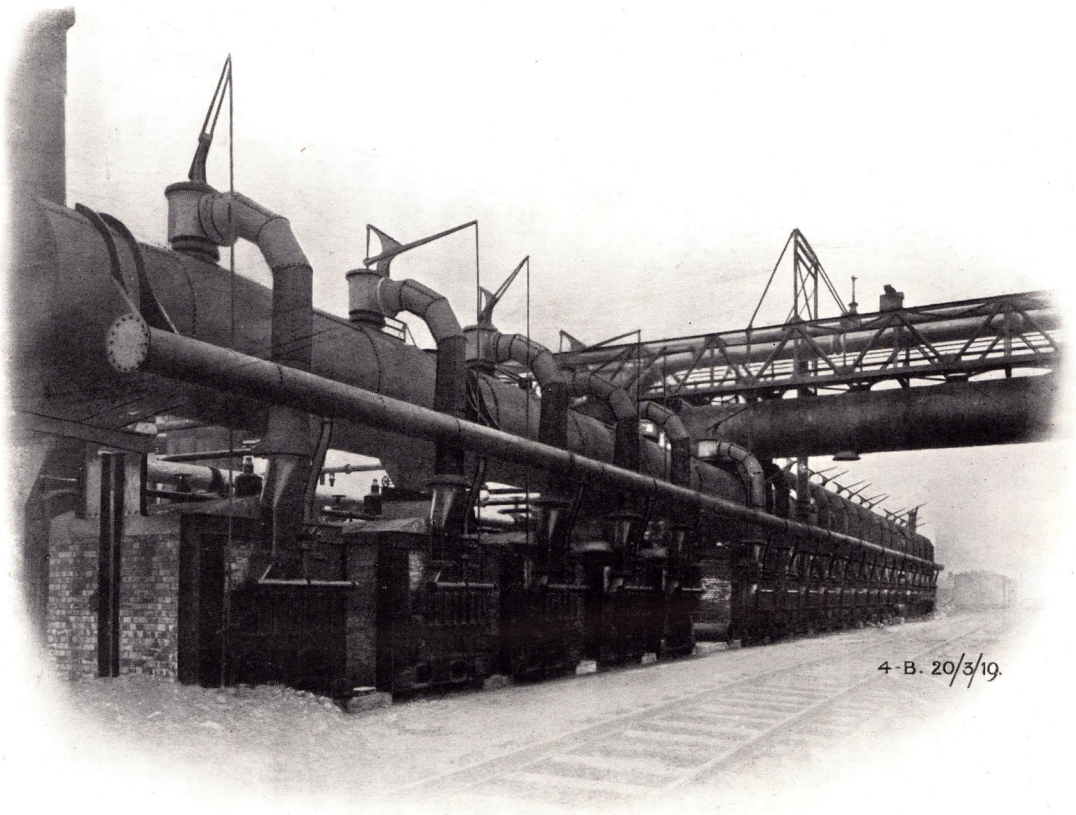
It is usually not necessary to remove or interfere in any way with existing hand-fired coal grates. The bars should be covered with a layer of broken fire-brick and small clinker. This bed should be made as air-tight as possible with the exception of a portion 9 in. to 12 in. long at the front of the grate, which should remain uncovered to allow of the admission of air for combustion.

It is further desirable that light sheet metal air doors should be fitted below the fire doors. These doors allow of very convenient regulation of air.

Galloways Ltd. have had wide experience of oil burning extending over many years, in connection with boilers for home and abroad, and in connection with forge furnaces in their own works and elsewhere.

During the recent coal shortage they have equipped many installations with oil burners, including many repeat orders.

Boilers for Iron and Steel Works



The above illustration, Fig. 28, shows an installation of Lancashire Boilers with special furnaces arranged for using Blast Furnace Gas.

A Galloway Patent Double-header Superheater is arranged in the downtake flue at the rear of each Boiler.

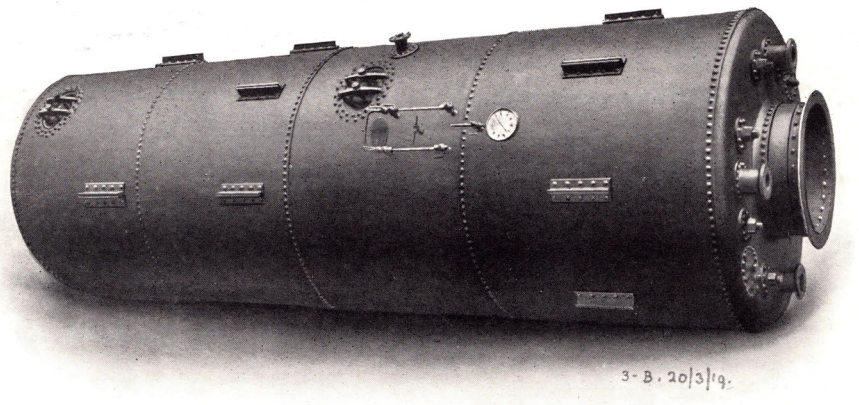


Fig. 29. Vertical Waste Heat Boiler.

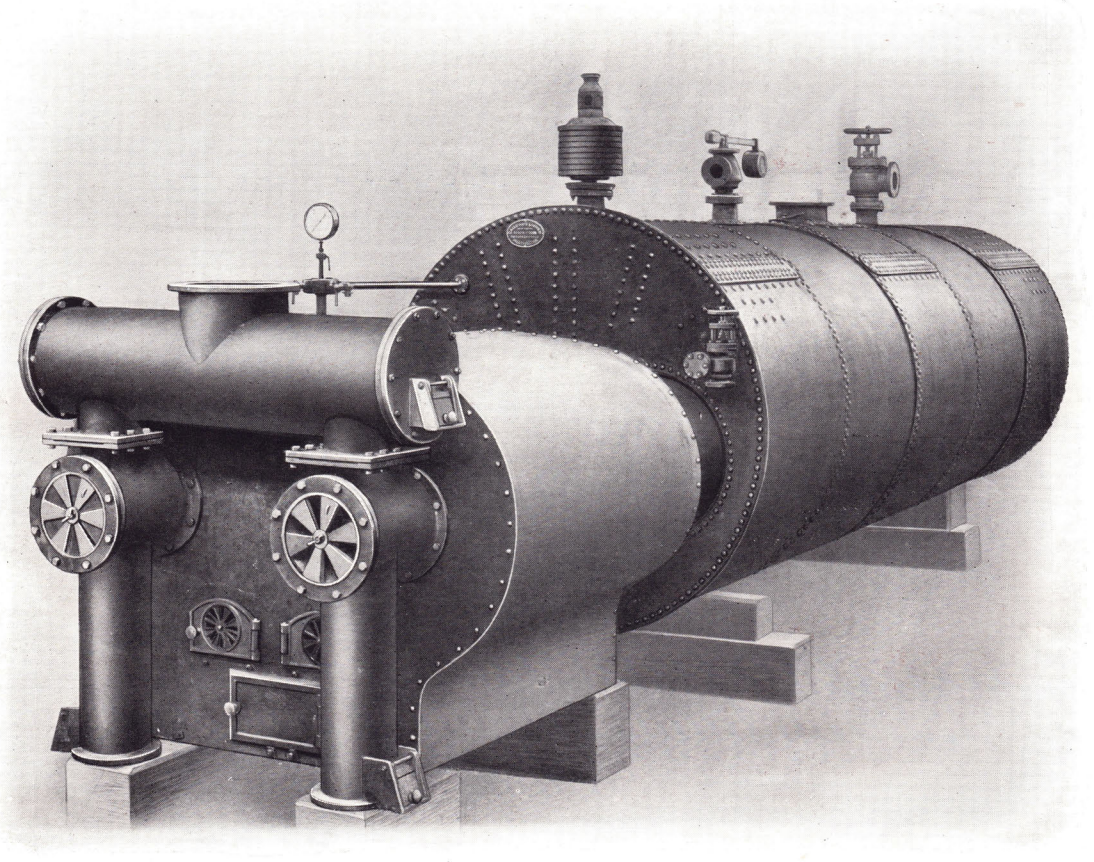


Fig. 30. One of a battery of five Lancashire Boilers, 30 ft. long, 9 ft. diameter, 160 lbs. working pressure, fitted with combustion chambers for gas firing and also fitted with grate for auxiliary hand firing.

The Galloway Patent Boiler

The foregoing remarks clear the way for a consideration of the reasons of the special features of the well-known " Galloway " Patent Boiler. Briefly, the boiler may be described as a Lancashire Boiler as far as the shell and end plates and the furnaces are concerned, but instead of continuing the furnace tubes as plain flue tubes for the remaining portion of their length, they unite into a common large chamber of kidney form which runs for the remaining length of the boiler. This kidney section is extraordinarily strong owing to the presence of a large number of Cone Tubes arranged in standard formation, and forming immensely powerful struts between the upper and lower plates of the kidney tube.

In the case of high pressure boilers these upper and lower plates are hydraulically stamped in special dies so that every portion of their width and length is of double curved form, and in this way the highest working pressures can be effectively dealt within, see Figs. 31 and 32.

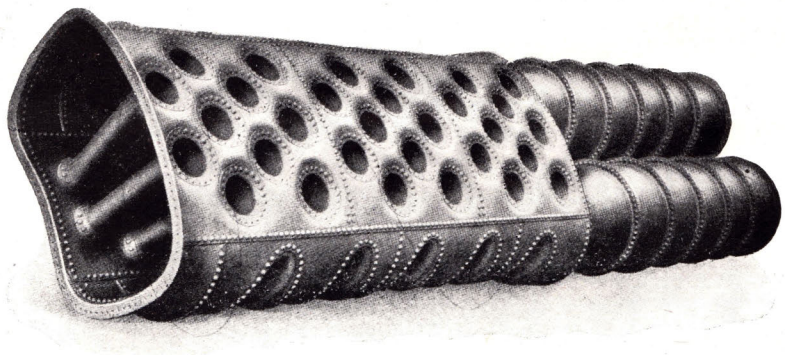


Fig. 31. Galloway Flue—High Pressure.

The general construction, see Fig. 32, is obviously much more costly than is the case with the plain flue tubes of the Lancashire Boiler, but considerable advantages are gained, namely :—

(*a*) Greatly increased heating surface, not less then 10% being added.

(*b*) Active upward circulation through the cone tubes, thus ensuring that the bottom or colder water of the boiler is in continual upward quick motion through the cone tubes and back again down the sides of the boiler.

(*c*) Owing to the staggered arrangement of the cone tubes, the flue gases follow a sinuous path through the nest of tubes, and no centre core of uncooled gases can escape without imparting its heat, as is the case with the ordinary Lancashire Boiler.

(*d*) As a consequence of the above, the efficiency of the boiler is increased to a marked degree, certainly not less than 5% and frequently 10% according to the working conditions.

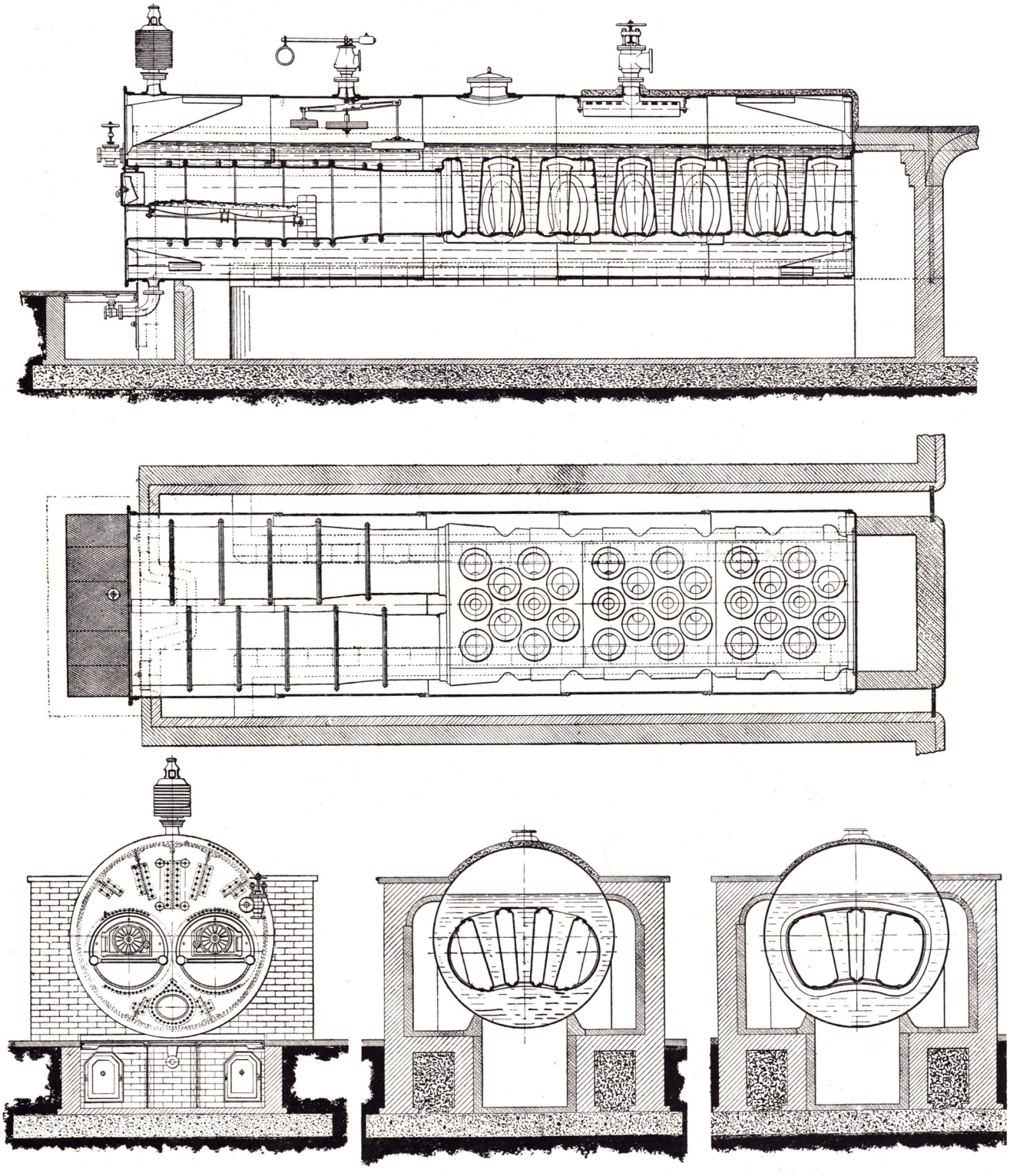


Fig. 32. Views of Galloway Patent Boiler.

Galloway Boilers for Continuous Working

It is an interesting fact that the sales of the " Galloway " Boiler take place principally to those Steam Users who work their boilers day and night throughout the week. Such conditions are favourable to the " Galloway " Boiler as the coal saving even on a 5% basis, makes a highly appreciated total at the end of the year. Very frequently where day and night work has been the rule, the net advantage conferred by a " Galloway " Boiler battery over that obtainable by a Lancashire Boiler battery has been so decisively proved as to ensure that all future orders have been on a " Galloway " Boiler basis. The marked superiority of the Galloway Boiler at high rates of evaporation is shown by the following figures :—

Relative Tests—"Lancashire" v. "Galloway" Boilers

	"Lancashire" Boiler	"Galloway" Boiler
Diameter of Boiler	8 ft. 0 in.	8 ft. 0 in.
Length of Boiler	30 ft. 0 in.	30 ft. 0 in.
Total heating surface.	985 sq. ft.	1,164 sq. ft.
Fuel fired per hour	1,421 lbs.	1,424 lbs.
Combustible burnt per hour	1,348 lbs.	1,317 lbs.
Water evaporated per hour	10,565 lbs.	11,485 lbs.
Dried Fuel fired per sq. ft. grate per hour	31 lbs.	31 lbs.
Water evaporated per lb. combustible from and at 212 degrees Fahr.	9·39 lbs.	10·39 lbs.

The above tests were made on two similar sized boilers, one of the " Lancashire " type and one of the " Galloway " type set side by side, working through the same Economiser and into the same chimney, and each boiler worked alternately. The tests were made by the staff of the British Engine, Boiler and Electrical Insurance Company, and show that the " Galloway " Boiler, at the stated rate of working, obtained 10% advantage.

An example of the economical advantage of a " Galloway " Boiler is worked out below on the following assumptions :—

Coal consumption per hour	10 cwts.
Working hours per week	144
Price of coal per ton	37/–
Advantage gained by " Galloway " Boiler assumed to be only :—	5%

On the above data the annual coal saving is as follows :—

$$5\% \ (\tfrac{1}{2} \text{ ton} \times 144 \text{ hours} \times 50 \text{ weeks per year} \times 37/-) = £333.$$

This £333 will, therefore after allowing liberally for interest and depreciation, give a handsome percentage saving on the increased capital cost of the boiler.

Apart, however, from the question of coal saving, the increased heating surface of the " Galloway " Boiler, and the increased efficiency, give a markedly increased maximum steam production as compared with a similar size of " Lancashire " Boiler. In actual practice this increased steam production is usually not less than 10%. In other words the " Galloway " Boiler is well known as an excellent steam raiser. A further advantage is obtained indirectly as a consequence of the rapid movement of the water inside the boiler due to the cone tubes.

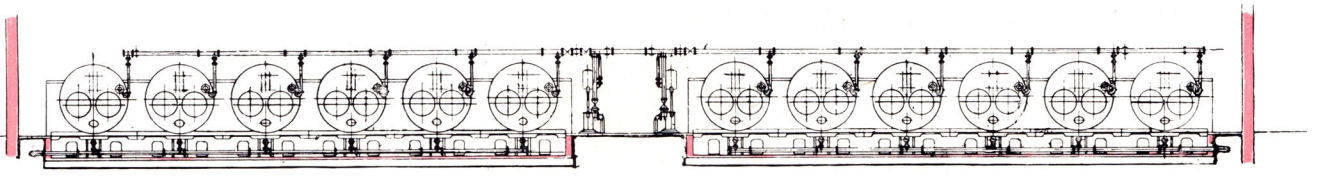
In " Lancashire " Boilers for frequently two hours after starting to work, the water at the bottom of the boiler is quite cold, and one's hand may be placed on the front end plate near the mudhole without discomfort although steam at full pressure is being generated at the moment in the Boiler. In a " Galloway " Boiler this imperfect circulation cannot and does not obtain ; the circulation is rapid, and as a result thereof, the liability of the flue tubes to " hogging " and straining is diminished in a remarkable degree and eventually leads to a reduction in the upkeep and wear and tear expenses. Particulars and rates of evaporation of the standard Galloway Boiler are given in the table below, and Fig. 33 shows a Galloway Patent Boiler viewed from the rear end.

Fig. 33.

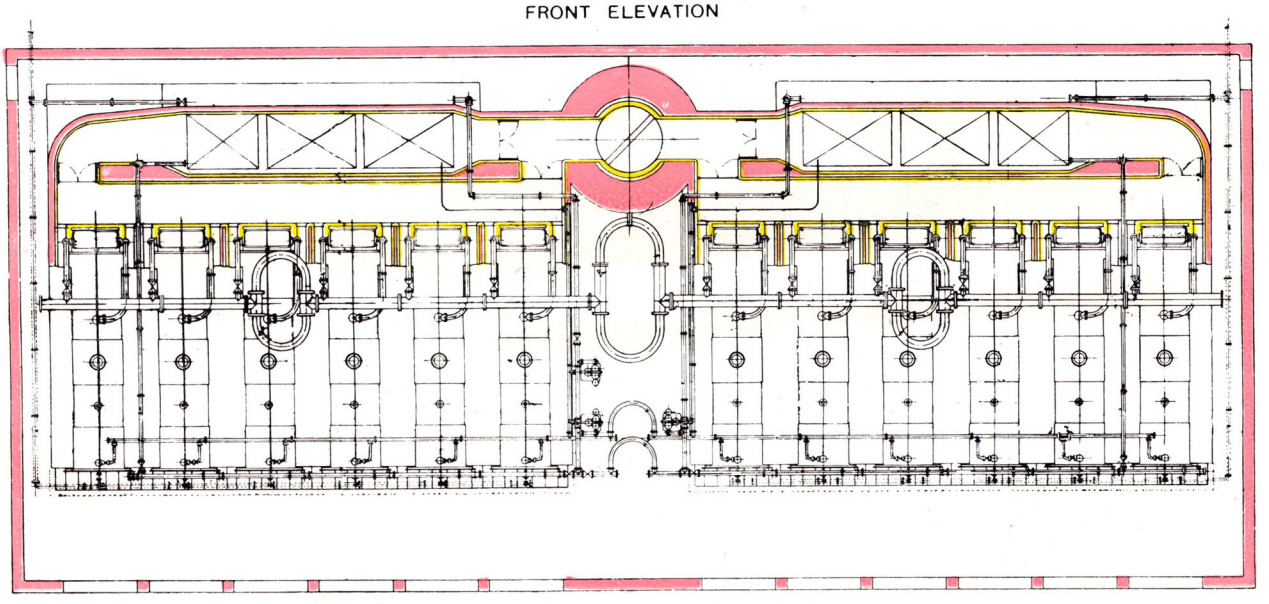
Standard " Galloway " Boilers.

No.	Size. Length × Diam.	No. of Cone Tubes	Heating Surface	Normal Grate Area	Outside Diam. of Furnace	Steam Evaporated per Hour, Lbs. Coal burnt per Sq. Ft. Grate per Hour			Approximate Net Weight. Working Pressure		Code Word
						20 lbs.	25 lbs.	30 lbs.	120 lbs.	160 lbs.	
	Ft. Ft. Ins.		Sq. Ft.	Sq. Ft.	Ft. Ins.	Lbs.	Lbs.	Lbs.	Tons.	Tons.	
1	14 × 5 6	6	300	14·5	2 1	2,500	3,100	3,700	7	—	**Adding**
2	16 × 5 6	8	350	16	2 1	2,700	3,400	4,100	7·5	—	**Among**
3	18 × 5 6	8	395	17·2	2 1	2,900	3,600	4,400	8	—	**Ample**
4	16 × 6 0	8	395	19·5	2 4	3,300	4,100	5,000	8	—	**Anoint**
5	18 × 6 0	11	445	21	2 4	3,500	4,400	5,300	8·75	—	**Artful**
6	20 × 6 0	11	495	22·5	2 4	3,800	4,800	5,700	9·5	—	**Ascarider**
7	22 × 6 0	14	555	22·5	2 4	3,800	4,800	5,700	10·3	—	**Ash**
8	20 × 6 6	15	570	23·2	2 7	3,900	4,900	5,900	10·5	12·5	**Ashdown**
9	22 × 6 6	15	605	25	2 7	4,200	5,300	6,400	11	13·25	**Asking**
10	24 × 6 6	18	675	27·5	2 7	4,600	5,800	7,000	11·8	14·5	**Aslant**
11	26 × 6 6	18	725	30	2 7	5,100	6,400	7,600	13	15	**Asleep**
12	24 × 7 0	18	735	29·7	2 9	5,100	6,300	7,600	14·5	17	**Asp**
13	26 × 7 0	20	795	32	2 9	5,400	6,800	8,200	15·5	18	**Aspect**
14	28 × 7 0	20	850	32	2 9	5,400	6,800	8,200	16·5	19	**Asperse**
15	30 × 7 0	25	925	32	2 9	5,400	6,800	8,200	17·5	20	**Assam**
16	28 × 7 6	20	925	35	3 0	5,900	7,400	8,900	17·75	22	**Assassin**
17	30 × 7 6	25	1,000	35	3 0	5,900	7,400	8,900	19	23·5	**Assayer**
18	28 × 8 0	25	1,070	38	3 3	6,500	8,100	9,700	20	25	**Assemble**
19	30 × 8 0	25	1,120	38	3 3	6,500	8,100	9,700	21	26	**Assent**
20	30 × 8 6	25	1,220	40	3 5	6,800	8,500	10,200	23·5	28·3	**Asset**
21	30 × 9 0	25	1,310	43	3 8	7,300	9,100	11,000	25·5	31·5	**Astor**

Basis.—8·5lbs. of water evaporated per lb. of coal. Boiler supplied with hot feed as from a Green's economiser.
The " Galloway " Boiler has considerably more heating surface than a Lancashire Boiler, and gives a distinctly higher efficiency, We recommend it as a sound business investment, especially where economisers are not fitted.



FRONT ELEVATION



PLAN

Fig. 34 above shows two batteries each consisting of six Galloway Boilers, 30 ft. long, 8 ft. 6 in. diameter, 160 lbs. per square inch working pressure, arranged to discharge into a common chimney erected between the two batteries.

Galloway patent Double-Header Superheaters are arranged in the downtake flue of each boiler.

The total steam generated is approximately 101,000 lbs. per hour under average conditions.

Fixing Galloway and Lancashire Boilers

The setting of the boiler in brickwork in its final position is a matter of importance, as it is necessary that the flues should be correctly proportioned throughout, and that ample room should be given for the free passage of the gases as well as for inspection. Galloways, Ltd., furnish special plans giving full details of the setting for all boilers ordered.

In both Galloway and Lancashire Boilers the hot gases after leaving the flue tube descend the downtake and return along the bottom flue, divide at the front end and pass back by way of the side flues and thence to the main flue, through the Economiser and away to the chimney.

In preparing the boiler seating good foundations and good housing are of great importance otherwise serious damage to the boiler in the way of corrosion may occur through dampness

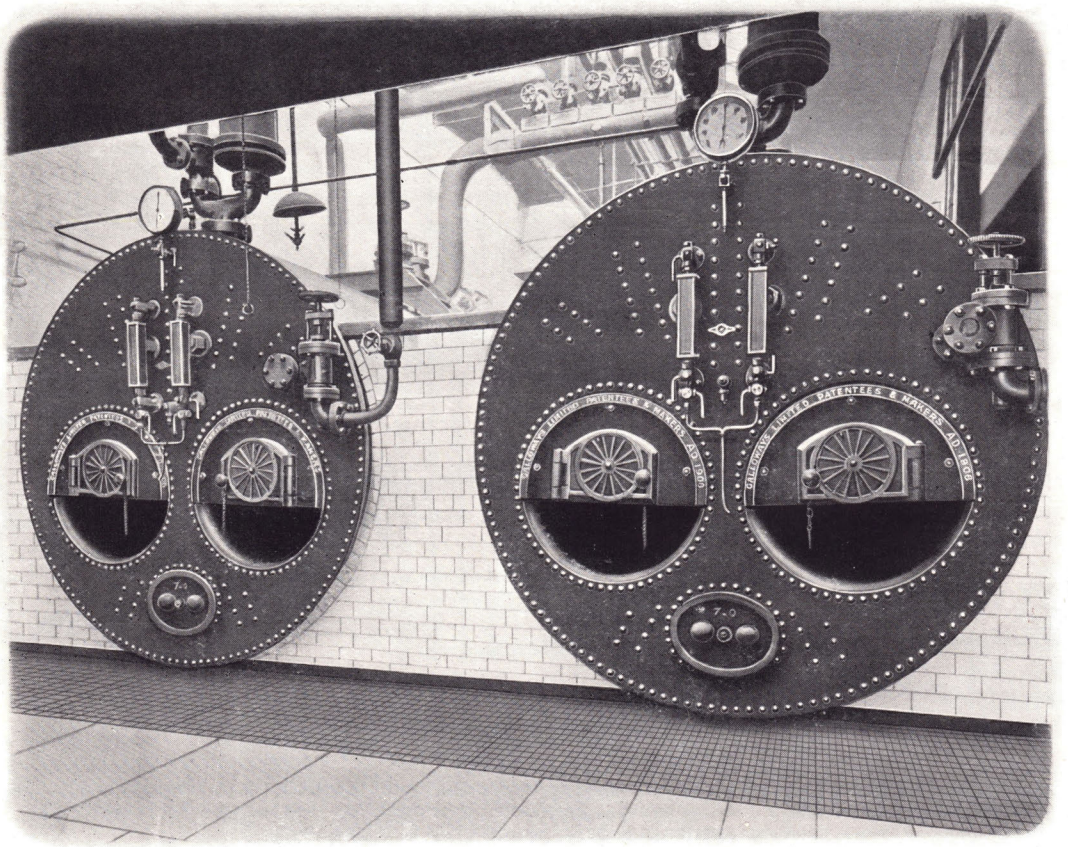
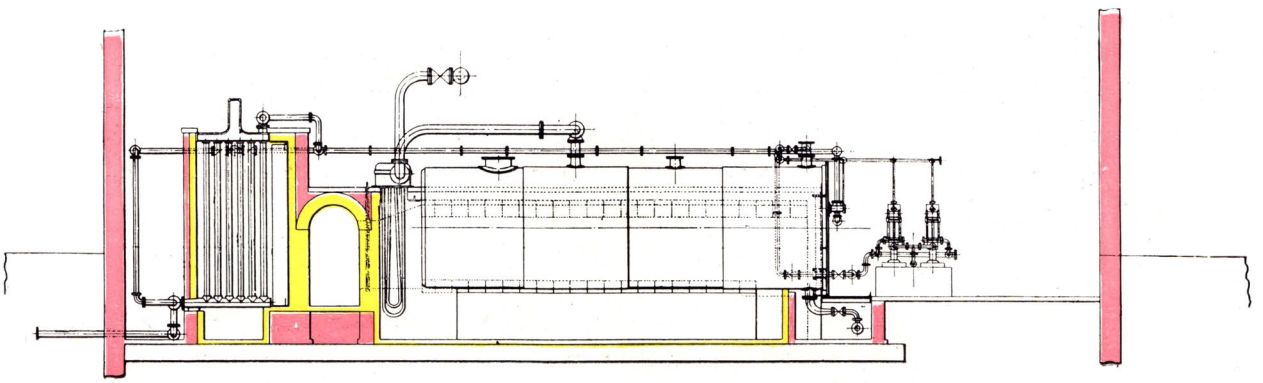


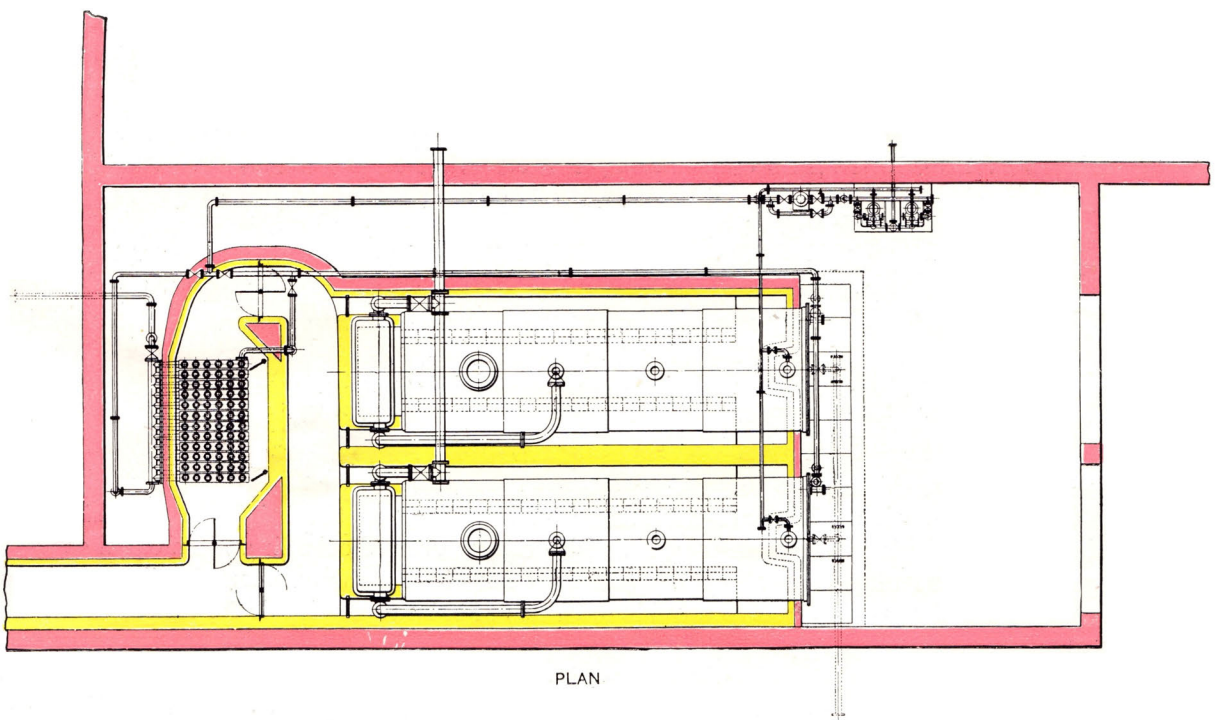
Fig. 35. Two Galloway Boilers, 28 ft. long, 7 ft. 6 in. diameter.

arising from wet ground or percolation. The foundations should be built with hard well-burnt bricks well bonded, and the internal faces of the flues where exposed to the hot gases, should be lined with fire brick. The Boiler itself should be supported upon fireclay blocks specially made for the purpose. These require to be packed so as to bed evenly against the Boiler plate, and also, require cutting so as to clear the rivets at the ring seams. The top of the slide flues should be covered with fireclay covers of special shape.

The special seating blocks and covers, as well as firebricks necessary to set the boiler can be supplied by Galloways, Ltd.



LONGITUDINAL SECTION



PLAN

Fig. 36. The illustration above shows seating and arrangement of a Boiler Installation, comprising two Galloway Boilers, 24 ft. long and 7 ft. diameter, 160 lbs. per square inch working pressure. The water evaporated by this plant is about 12,600 lbs. per hour.

The Boiler should be set so that the machined faces of the blocks on the top of the boiler are level transversely. But in a longitudinal direction the boiler should have a fall of $\frac{1}{2}$ in. in each 10 ft. of length towards the front end, so as to ensure the boiler being thoroughly drained when it is emptied for cleaning and inspection.

All boilers should have the crowns covered with non-conducting material to prevent radiation losses. The material should be such that it can be readily removed for examination purposes ; bricks are not recommended for covering boilers.

All boilers should be housed in well ventilated buildings, arranged with an open front if possible.

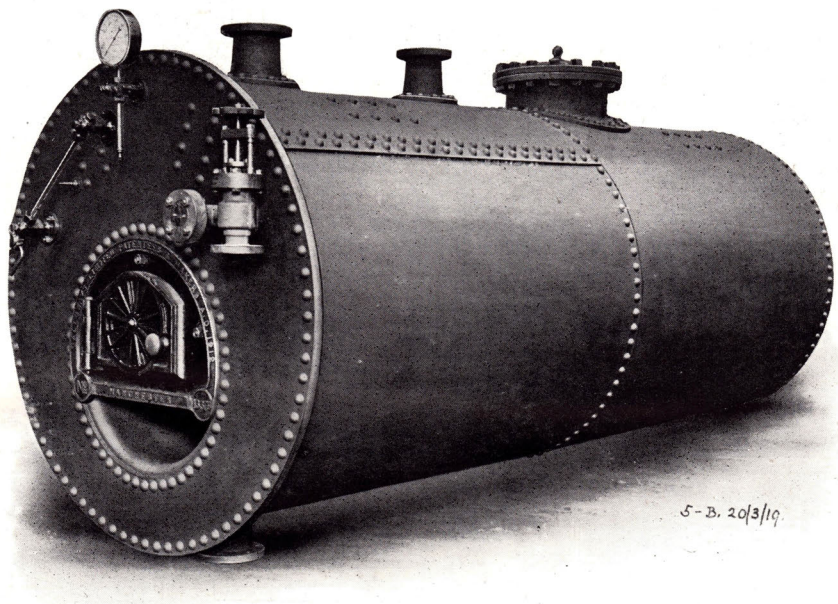


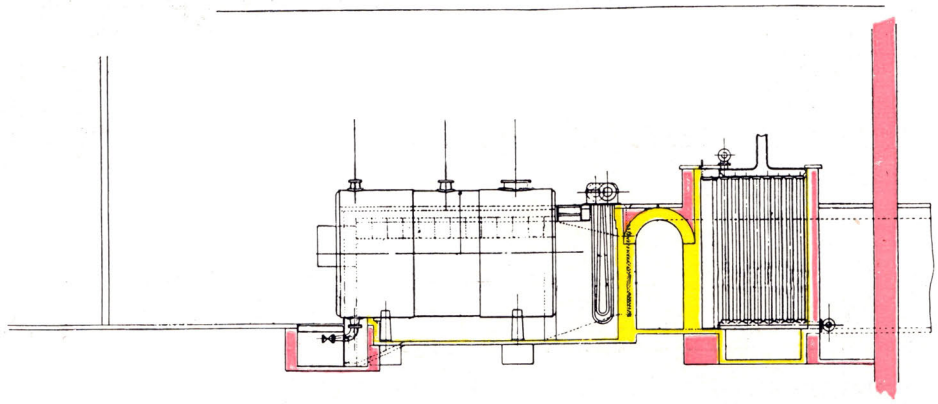
Fig. 37. An improved Cornish Boiler with a single flue is illustrated above. Large numbers of this type of Boiler are supplied to small Works and Laundries.

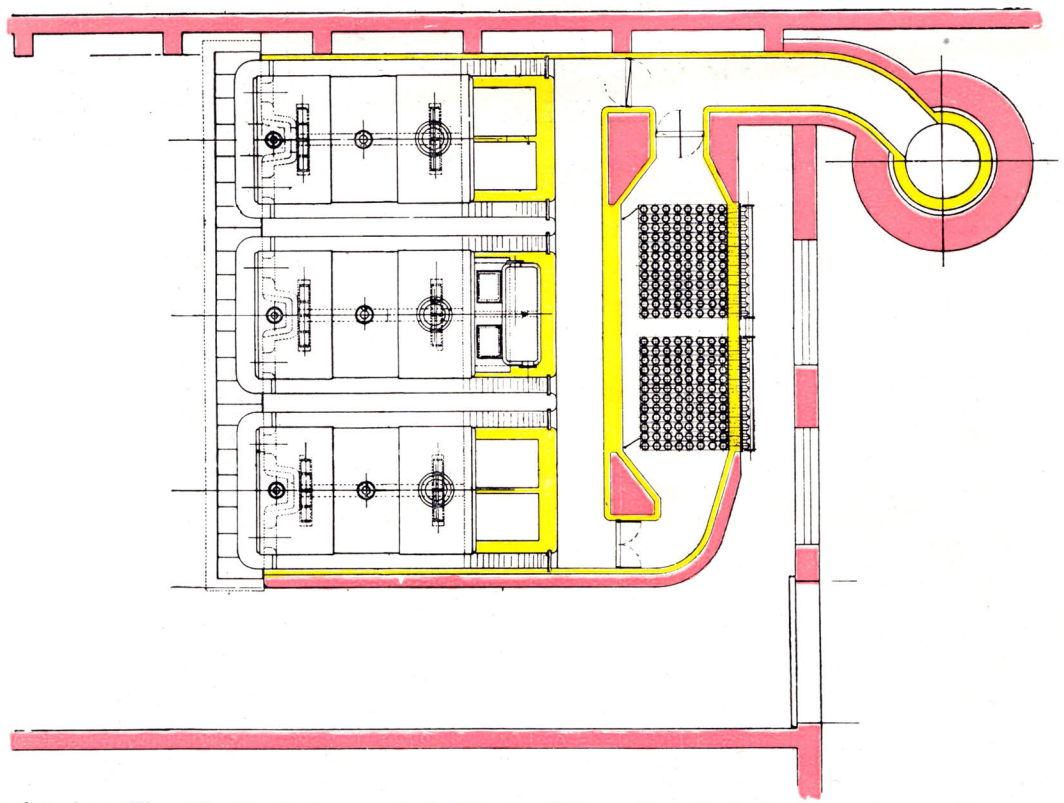
Chimney

The draught, where there are no fans or jets, depends on the height of the chimney ; and its intensity depends on the difference in density of a column of cold air and an equal column of hot gases. The chimney should be of ample height and size for the number of boilers working into it, and we are always prepared to provide drawings of chimneys suitable for ranges of boilers of any number.

Many points must be taken into consideration in determining the area and height of a chimney, such as the type of boiler, the quality of the fuel, the rate of firing, the arrangement of the Economiser, the condition of brickwork as regards air leakage, the features of the surrounding country, the Local Building regulations, etc. All main flues should be arranged with easy curves, and where the gases from separate ranges enter the chimney on opposite sides, a division wall should be built in the base of the chimney to avoid eddy currents which would otherwise be created.

As a rough guide chimneys 100, 130 and 165 feet high will give a draught suitable for burning 20, 25 and 30 lbs. of bituminous steam coal per square foot of grate per hour respectively under satisfactory conditions.





The line drawing, Fig. 38, illustrates an installation of three Dry-Back Boilers, size 14 ft. long by 8 ft. diameter. A Galloway Patent Superheater is fixed at the back of each Boiler. This installation will generate approximately 15,600 lbs. of steam per hour.

Dry-Back Boiler

This is a type which has obtained considerable favour, and is specially suitable where space is restricted. The two furnaces extend right to the back of the boiler, along which the flame passes, afterwards proceeding along the fire tubes, which also extend from end to end of the boiler, thence round the shell to the chimney. The construction is on the same lines as the " Lancashire " type, with the exception that fire tubes are provided, and the staying above these is effected by means of longitudinal bar stays (see fig. 39). We build this type of boiler in any any size that may be required.

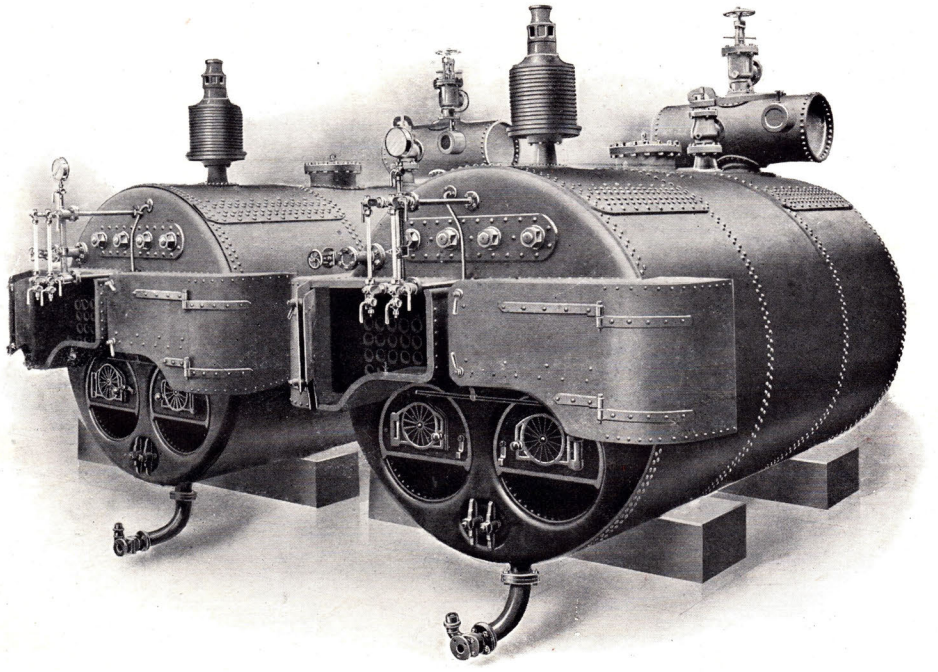


Fig. 39.

Standard Dry-Back Boilers

No	Size Length × Diam.	Number of		Heating Surface	Grate Area	Outside Diam., Furnaces	Outside Diam., Tubes	Steam Evaporated per Hour, Lbs.			Approximate Net Weight		Code Word
								Coal burnt per Sq. Ft. Grate per Hour			Working Pressure		
		Furnaces	Tubes					20 lbs.	25 lbs.	30 lbs.	120 lbs.	160 lbs.	
	Ft. Ft. Ins.			Sq. Ft.	Sq. Ft	Ft. Ins.	Ins.	Lbs.	Lbs.	Lbs.	Tons	Tons	
1	8 × 5 0	1	20	290	5	2 1	4	900	1,100	1,300	3·8	4·4	**Babe**
2	9 × 5 6	1	28	412	7	2 4	4	1,200	1,600	1,900	4·6	5·5	**Bacon**
3	10 × 5 6	1	28	450	8·5	2 4	4	1,400	1,900	2,200	4·9	5·8	**Badge**
4	12 × 6 0	1	32	620	12·4	2 7	4	2,200	2,800	3,400	6·9	7·8	**Baford**
5	12 × 6 6	1	36	695	14	3 0	4	2,500	3,200	3,700	7·6	9·0	**Bags**
6	12 × 7 0	1	48	864	15·2	3 3	4	2,700	3,400	4,000	9·2	10·8	**Bahig**
7	13 × 7 6	1	60	1,120	17	3 5	4	3,000	3,800	4,600	10·8	12·7	**Bailer**
8	14 × 8 0	2	76	1,228	23·3	2 4	3	4,100	5,200	6,200	12·7	14·8	**Bakart**
9	15 × 8 3	2	80	1,380	28·3	2 7	3	5,100	6,300	7,500	14·0	16·8	**Bald**
10	15 × 8 6	2	80	1,560	32	2 7	3·5	5,700	7,200	8,600	15·5	18·1	**Bannock**

BASIS.—9 lbs. of water evaporated per lb. of coal. Boiler supplied with hot feed as from a Green's economiser.

Special Boilers with Furnaces arranged to burn any type of Fuel

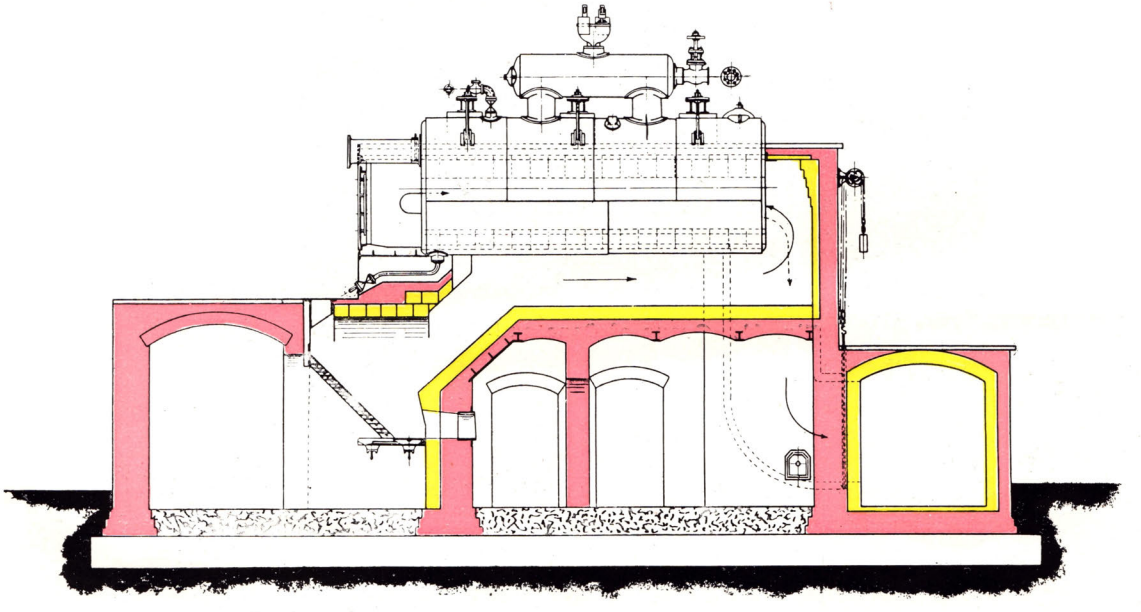


Fig. 40 illustrates a special multi-tubular Boiler underfired with furnace for burning Bagasse or Refuse fuel.

In this case a large furnace is placed below the boiler, and the hot gases pass underneath the boiler, through the fire tubes, and return by the side flues to the main flue, and thence to the chimney.

The Galloway Cone Tube

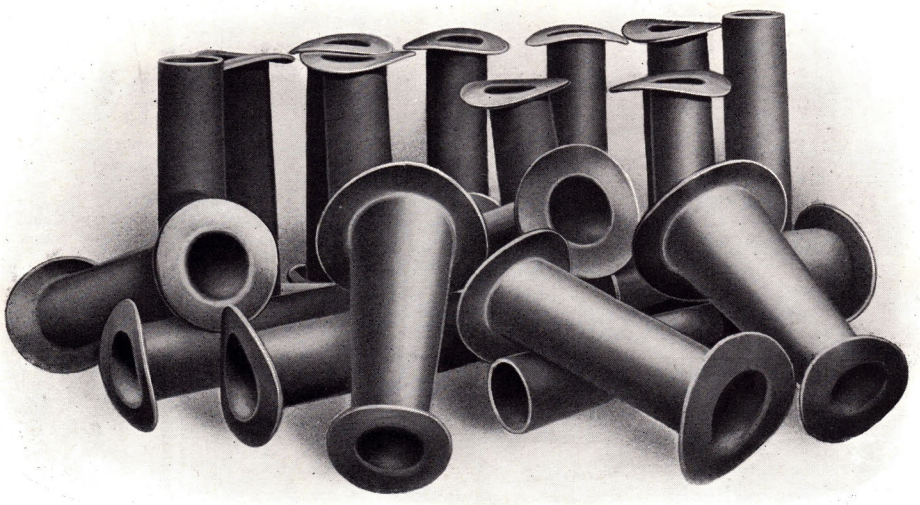


Fig. 41. Group of Cone and Parallel Tubes.

One of the most important departments at the Boiler Works is that devoted to the manufacture of Galloway Tubes, Fig. 41, which have had such a high reputation for a number of years.

They are not only used by ourselves, but large quantities are supplied to the trade in all parts of the world. Special plant has been developed for making the tubes in large numbers.

The tubes not only increase the circulation of water, a matter of highest importance when considering the durability of a boiler, but the additional heating surface and the important matter of stiffening the flue are great advantages obtained by the use of the Galloway Tubes. We would again observe that if a few of these tubes are found to be of such advantage as to be generally introduced into an ordinary Lancashire Boiler, it must be evident that a Galloway Boiler which contains a much larger number, possesses proportionate advantage.

The tubes are made of all lengths up to 4 feet 6 ins. Up to 2 ft. 0 in. long the diameters are 8 ins. and 4 ins. respectively, to 2 ft. 3 ins. long the diameters are 9 ins. and $4\frac{1}{2}$ ins. and beyond that length the diameters are $10\frac{1}{2}$ ins. and $5\frac{1}{2}$ ins. which have been found from practice to be the best proportions.

The Galloway Patent Superheater

Economy

Superheated steam leads to a saving of from 15 to 30% in the steam consumption of Engines, and is specially advantageous where there are long lengths of steam piping, as superheating reduces both condensation loss and drop in pressure.

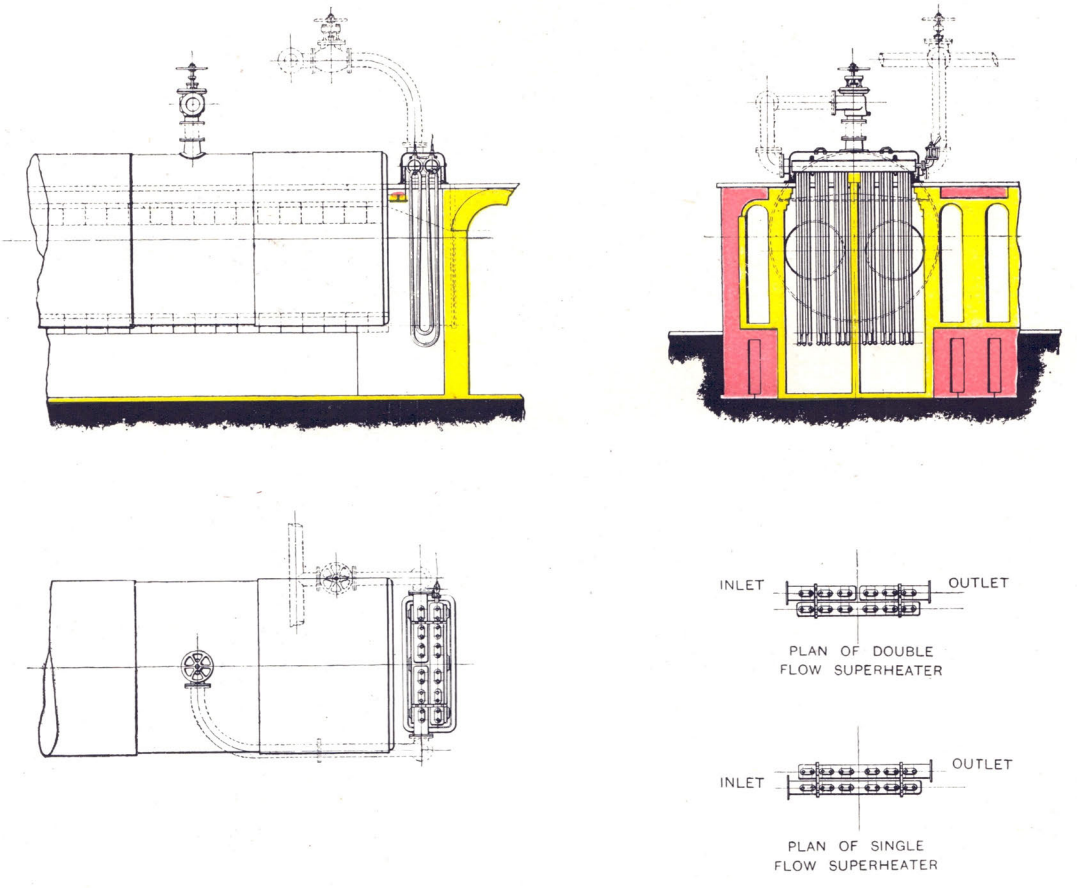


Fig. 42. Sketch showing position of Superheater.

Increased Output

Superheated steam also increases the power which can be obtained from a given boiler by 15 or 20% and in many cases adding a superheater is the cheapest way of increasing the capacity of the boiler plant.

Galloways, Ltd., manufacture two types of superheaters, one a single-flow, the other a double-flow type for higher degrees of superheat. Both types embody all the essential features of reliable and efficient superheaters. They are for use in the downtake at the rear of " Lancashire " and " Galloway " Boilers, Fig. 42, where the tubes through which the steam is passing are impinged on by the gases leaving the internal flues of the boiler.

Wrought Steel Throughout

The Galloway Patent superheaters are *made of wrought steel throughout, and all parts* are of circular form, thus securing the maximum durability and strength.

Arrangement of the Single-flow Superheater

The single-flow superheater, consists of two horizontal headers of circular section, Fig. 44, connected by a number of solid-drawn weldless steel tubes of " U " form ; the tubes are $1\frac{3}{16}$ ins. outside diameter.

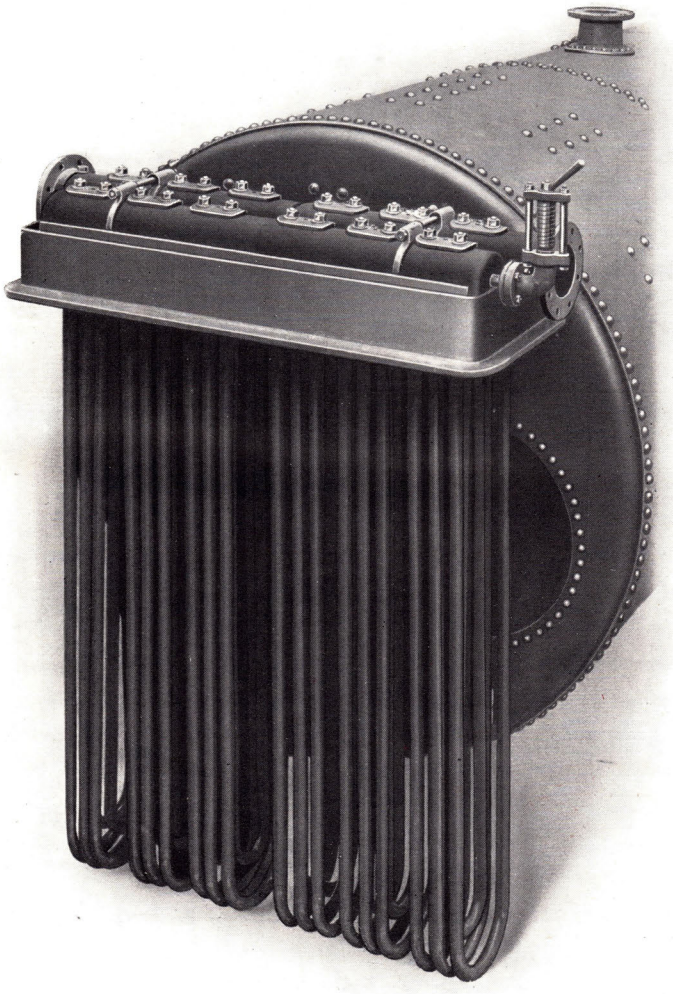


Fig. 43. Double-Flow Superheater, cover removed.

The steam passes from one header to the other by way of the tubes ; these tubes, but not the headers, being placed in the path of the hot gases.

The two headers are rigidly stayed together, *thus preventing racking strains due to vibration and expansion.*

Uniform heating of all the steam must take place, seeing that the steam path from the inlet branch to the branch contains the same length of header path and of tube path by whichever tube the steam passes from one header to the other.

Arrangement of the Double-flow Superheater

The double-flow superheater, Fig. 43, which is installed to give a higher superheat than the single-flow type, is similar in construction, with the exception that one of the headers is divided in its length to form two separate headers. The steam is passed from the short inlet header, by way of the first group of tubes, into the long header. From the long header the steam is allowed to pass through the second group of the tubes into the short outlet header. The steam, therefore, has a double pass through the tubes which are arranged in the path of the hot gases in the downtake.

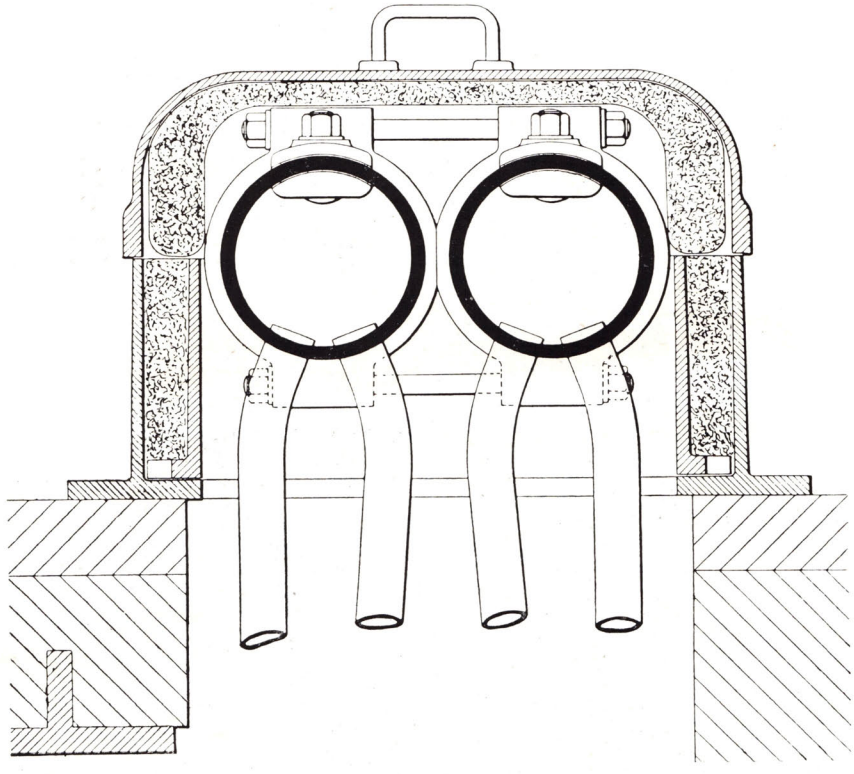


Fig. 44. Section through horizontal headers.

Protection

The superheaters are protected from damage and radiation loss by a double walled cast-iron box, with cover as illustrated in Fig. 44.

Removal

The illustration, Fig. 45, shows the ease with which the superheater can be lifted out if required for any reason. The steam piping is not disturbed as the superheater joints " A " and " B " are both vertical and the superheater is lifted vertically from the clips " D."

If required a crossover pipe " C " can be inserted so that the boiler can supply saturated steam. For the double-flow superheater this pipe is a straight length, the inlet and outlet branches being opposite.

Accessibility

By removing the cast-iron cover and the hand-hole doors in the headers, every tube can be inspected and cleaned.

Testing

All superheaters are tested hydraulically to 500 lbs. per square inch.

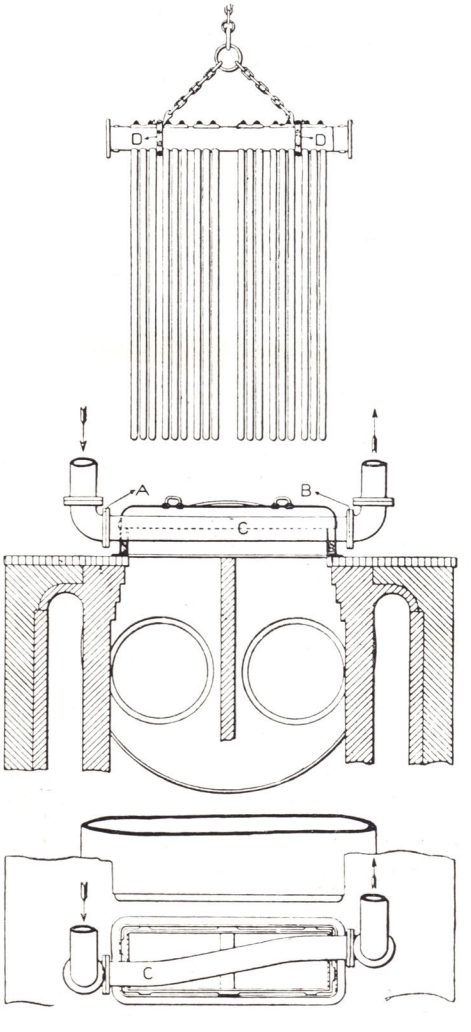


Fig. 45.

Particulars of Standard Superheaters

The following table gives particulars of Standard Superheaters. The diameter of boiler referred to is based on "Lancashire," "Galloway," or similar boiler practice, but these superheaters can be fitted to most other forms of boiler. For high temperatures of superheat and larger boilers special multiple flow superheaters quoted on application.

Diameter of Boiler	Number of Tubes	Heating Surface	Shipping Dimensions	Approximate Weight	
				Net	Gross
Ft. In.			Ft. Ins. Ft. Ins. Ft. Ins.	Cwts.	Cwts.
6 0	20	145	9 6 × 5 8 × 2 3	15	17
			5 0 × 3 0 × 2 3	6·5	8
6 6	25	195	9 6 × 6 4 × 2 3	18	22
			6 0 × 3 0 × 2 3	8	10
7 0	25	195	do. do.	do.	do.
7 6	25	195	do. do.	do.	do.
8 0	30	235	9 6 × 7 6 × 2 3	20	25
			7 0 × 3 0 × 2 3	10	12
8 6	30	235	do. do.	do.	do.
9 0	30	235	do. do.	do.	do.

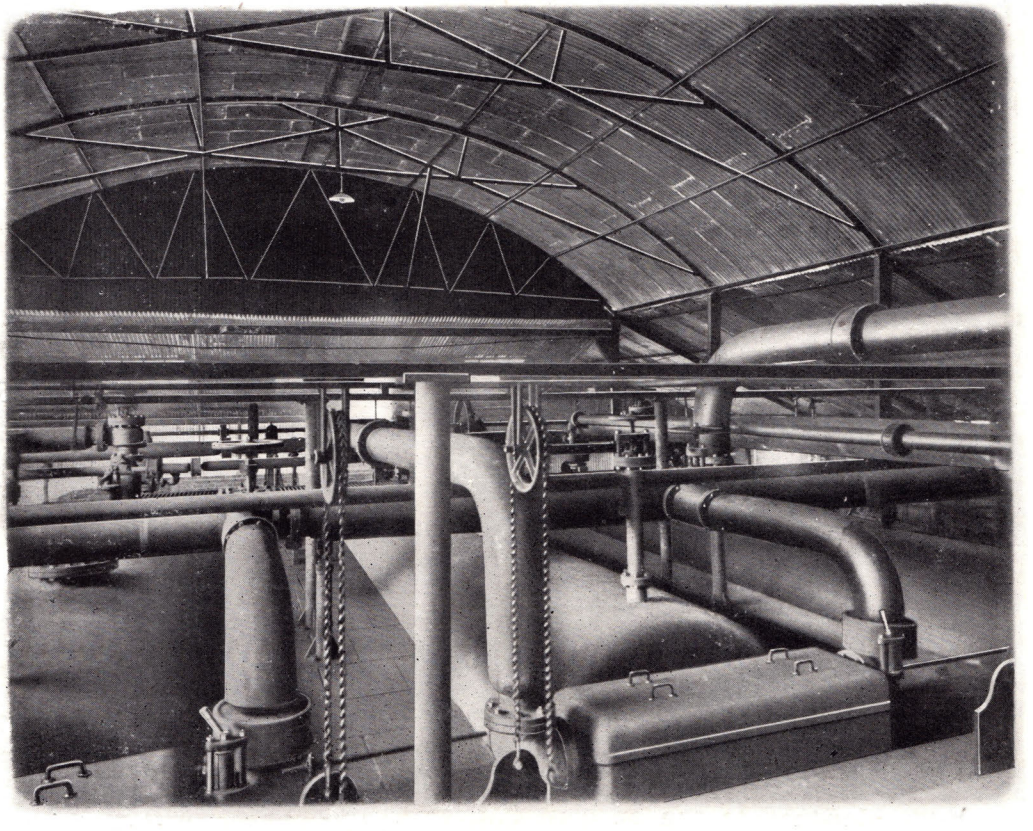


Fig. 46. The illustration given above is another view of the installation shown in Fig. 6. The Galloway Patent Superheaters are clearly shown at the rear of the Boilers.

Engines : Boilers

For COLLIERIES, STEELWORKS, FACTORIES, PUMPING

Constructed to give highest Economy and Reliability

Boiler Department

LANCASHIRE, GALLOWAY, WATER-TUBE, DRY-BACK, WASTE HEAT, LOCOMOTIVE AND MOTOR WAGGON BOILERS. PATENT MULTIPLE FLOW SUPERHEATERS, BOILER FITTINGS, TUBES, STEEL BLOCKS AND MANHOLES. (Trade Supplied.) KIERS, STILLS, KILNS, TANKS AND STEEL PLATE WORK. ELECTRIC WELDING AND METAL ELECTRODES.

Engine Department

UNIFLOW ENGINES, 150 to 5,000 I.H.P.
DROP VALVE ENGINES arranged for Heat Extraction
CONTINUOUS RUNNING ROLLING-MILL ENGINES
REVERSING ROLLING-MILL ENGINES, up to 20,000 I.H.P.
BLAST FURNACE AND BESSEMER BLOWING ENGINES
PATENT FRICTIONLESS STEEL PLATE AIR VALVES
PUMPING ENGINES, arranged to drive RECIPROCATING or CENTRIFUGAL PUMPS
HYDRAULIC PUMPING ENGINES, ACCUMULATORS, HEAVY FLANGING PRESSES

LARGE GAS ENGINES 1,000 B.H.P. upwards

The Gas Engine is of the double-acting four-cycle type; designed to run on blast furnace gas, coke oven gas, a mixture of these gases, or on producer gas

They are built for driving electric generators, both D.C. and A.C. types, also blowing tubs for blast furnaces